THE UNIVERSITY OF ALBERTA

THE INJURY SEVERITY SCORE:
ITS ROLE IN EVALUATING THE CARE OF THE INJURED PATIENT

by

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE IN EXPERIMENTAL SURGERY

DEPARTMENT OF SURGERY

EDMONTON, ALBERTA

FALL, 1982

ABSTRACT

Accidental death is the leading cause of death in persons under forty years of age. The majority of these deaths arise from motor vehicle accidents. Canada has one of the highest motor vehicle accident mortality rates in the world. The mortality rate on Alberta roads is above the national average. The goals of this research project were to define the patient population affected by all types of accidents and to evaluate the Injury Severity Score as an index of morbidity and mortality in the injured patient.

Three hundred fifty-three victims of blunt trauma treated at University of Alberta Hospital during 1979 were studied retrospectively. All patients studied had an Injury Severity Score greater than 10. The overall mortality was 13.3 percent. Sixty-seven percent of the victims were injured outside the city of Edmonton, thirty-nine percent were from greater than 150 kilometers away. The mortality rate in this group of one hundred thirty-seven patients was 17.5 percent.

As an index of morbidity the Injury Severity Score correlated with length of hospital stay ($r = 0.98$) and number of surgical procedures ($r = 0.97$). As a predictor of mortality in all patients except those with isolated head and spinal injuries there was a strong correlation ($r = 0.97$). The mortality rate of the group of patients with isolated had and spinal injuries was significantly greater than those with other types of injuries but the same Injury Severity Score (χ^2 $p < 0.01$).

In conclusion, the multiple trauma patient population has a significant morbidity and mortality. The Injury Severity Score is an accurate index

of morbidity and of mortality, except in those patients with isolated head and spinal injuries. Variations in mortality between the rural and urban groups of patients and amongst different regions, needs to be studied prospectively and in greater detail.

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CHAPTER 1 INTRODUCTION

The impetus for this research project comes from a concern for the care of the accident victim. As will be discussed below, accidental death is the leading cause of death in Canada,[51,69] the majority arising from motor vehicle crashes. Working in any major hospital center one quickly appreciates how many victims there are and the tremendous morbidity and mortality inflicted.

Prior to this project, in Alberta, no study had been undertaken by the medical profession to assess the volume and types of injuries in these accident victims. The statistical information readily available relates to numbers of accidents, persons injured and deaths.[69] This information is currently collected by the various police departments and the Office of the Medical Examiner. The only information collected on the surviving accident victims is found in hospital medical records and in the Alberta Health Care Insurance Plan data registry. This information is currently not organized into a usable fashion for medical researchers.

The goals of the research project were two-fold. The first goal was to obtain an accurate estimate of the volume of multiple trauma patients treated at the University of Alberta Hospital. Additionally the profile of the accident victims, where they come from, the morbidity and the mortality were of specific interest. This information was sought to obtain a clearer picture of the magnitude of the problem and to obtain a more accurate estimate of the cost to society.

The second goal of the study was to evaluate the Injury Severity Score[4] as a research tool in describing the patient with multiple injuries. This score, developed by Baker et al,[4] is gaining acceptance as a standard method of classifying the injured patient. While many studies exist corroborating its usefulness and applicability, it has rarely been used in Canada and had never before been applied to a group of injured patients in Alberta. It was hoped that by familiarizing ourselves with the Injury Severity Score, a further definition of its strengths and weaknesses might be obtained.

Within the thesis that follows the study done to achieve the project's goals will be described. A review of the literature of the severity indices in general, and the Injury Severity Score in particular, is included to allow for a better understanding of their formulation and their uses. A discussion of the trauma unit concept and the principles involved in the evaluation of the care delivered by a trauma unit is also undertaken. The specific role of the Injury Severity Score in this procedure will be outlined.

In summary, the research project was done to define the problem of the multiply injured patient as it existed in the University of Alberta Hospital in 1979. Using the information obtained as a foundation, it is hoped that future areas of study will be defined and that efforts in improving the care of the critically injured patient will be forthcoming.

CHAPTER 2 STATEMENT OF THE PROBLEM

2.1 The National Picture

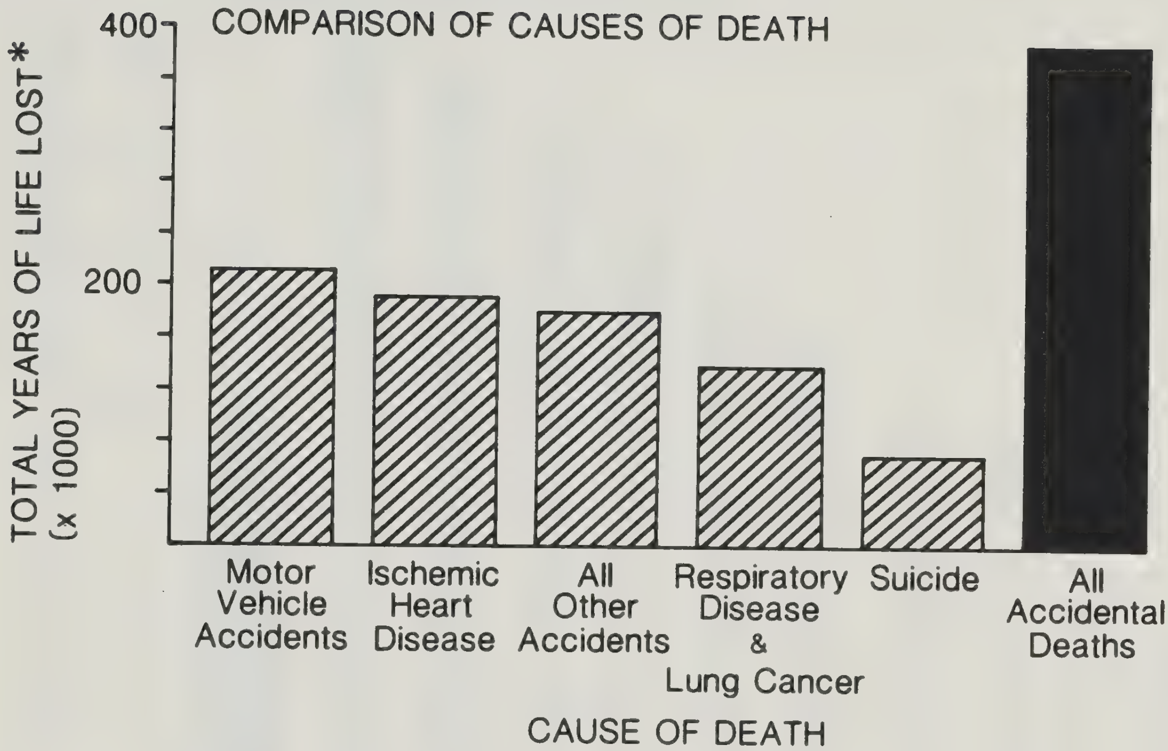
Motor vehicle accidents are the leading cause of death in persons under 35 years of age in Canada.[51] This represents approximately 5500 deaths annually. Because the majority of the victims are in their twenties, the aggregate loss of young life robs society of those in their most productive years. If one considers the lost years, based on an average life span of 70 years, accidental deaths of all types take a greater toll than heart disease or respiratory disease and lung cancer.[51] (Fig. 1). The Canadian fatality rate from motor vehicle accidents in 1979 was 19 deaths per 100,000 population. This figure places Canada amongst the highest fatality rates in the industrialized world and it is twenty-five percent greater than the rate in the United States.[18]

The cost to society in dollar terms is incalculable. It is known that all accidents account for approximately 3.1 million hospital bed-days annually, which on a conservative cost estimate of $200 per day, amounts to $620 million per year. This does not include the various physicians' fees, investigations, lost work time, insurance costs, etc. Whatever the precise figure, the total cost is extremely high, variously estimated at up to $2 billion per year.

2.2 The Alberta Picture

Within Canada regional variations exist (Fig. 2). In 1979, Alberta had a fatality rate of 34 deaths per 100,000 population, well above the national rate. Interestingly, although Alberta was also above the

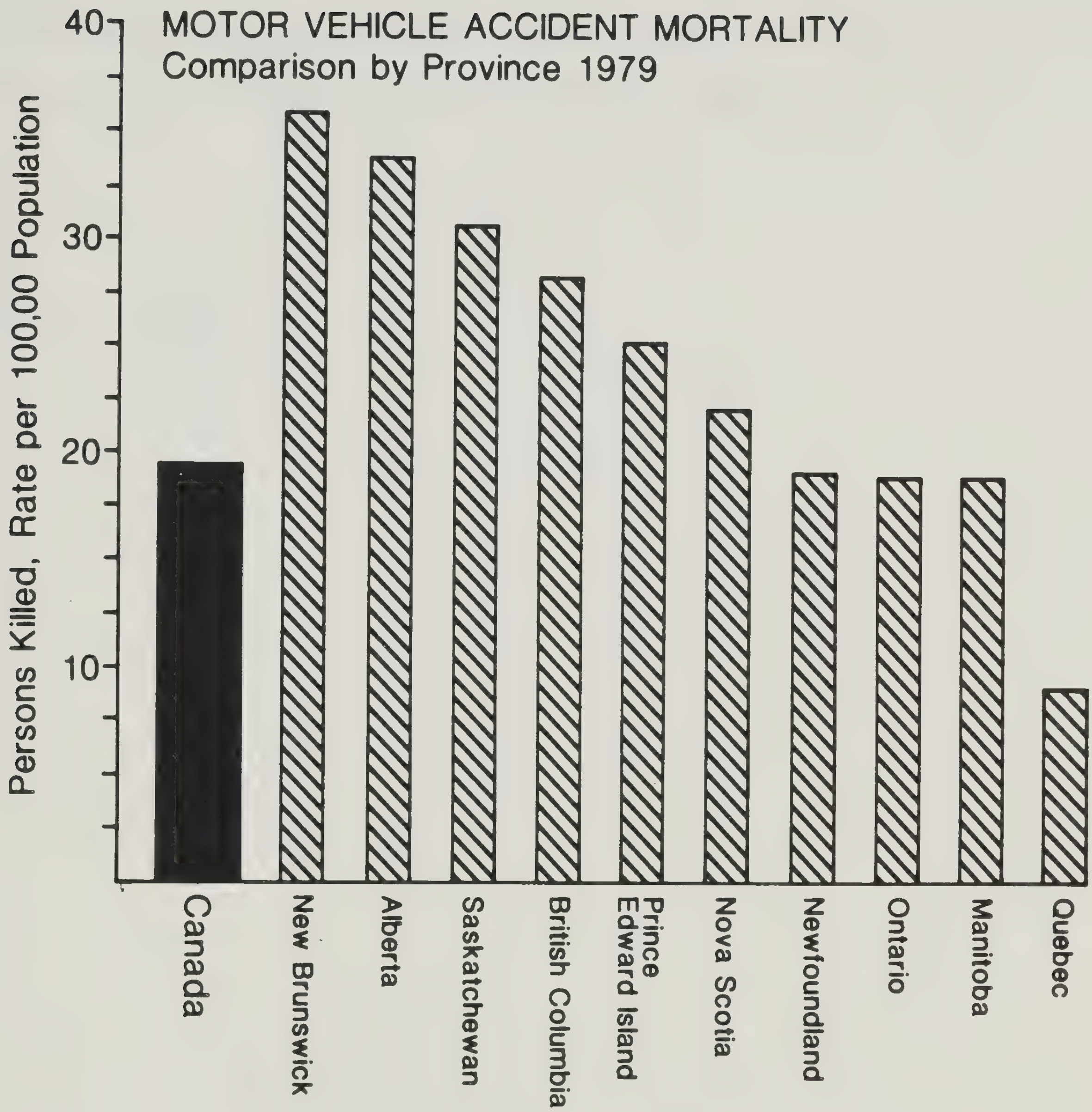
Figure 1



* based on an average
life expectancy of 70 years

Source: Lalonde, M. A New Perspective on the Health of Canadians. Ottawa, 1974

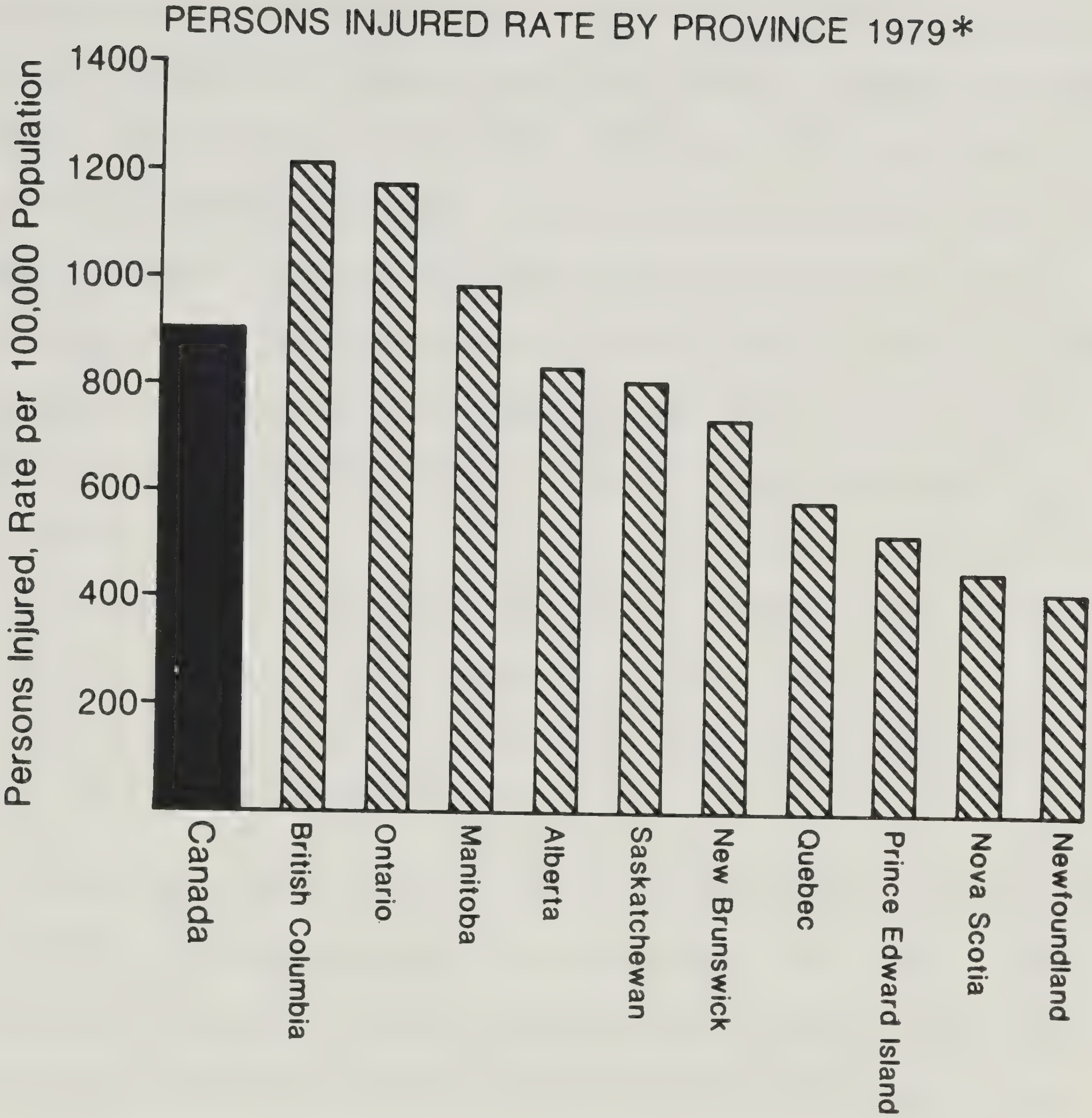
Figure 2



Source: Statistics Canada, Catalogue 85-205, Ottawa 1979

national average in the accident rate, it was below the national average in the persons injured rate (Fig. 3). This might suggest that the accidents involving personal injury caused more severe injuries or that the care provided is below average. It is well recognized that the mortality from accidents in rural areas is much higher than accidents in urban areas[76] and if Alberta had a high proportion of rural accidents in 1979, this statistical discrepancy might be explained.

Figure 3



*Source: Statistics Canada Catalogue 85-205, Ottawa, 1979

CHAPTER 3 THE SEVERITY INDICES - LITERATURE REVIEW

3.1 The Need for Severity Indices

Despite the enormous costs of health care delivery to the trauma patient and the significant loss of life caused by accidents, public pressure to adequately measure the effectiveness of treatment has been slow to develop and it was not until the early 1970's that various methods of classifying multiple trauma patients by overall injury severity began to appear. Over the past ten years there has been a gradual evolution of many numerically based indices to aid in the quantification and characterization of the accident victim. With enormous public moneys being invested in this area the onus has gradually shifted to the medical profession to prove to the public that the money is being properly spent on effective methods of care. This has created a need to develop an index of injury severity so that a very subjective criterion, the threat to life, can be accurately and objectively measured and thereby allow for a more accurate assessment.

When dealing with any study population, one is left with the task of defining and describing the group accurately. This is done using a variety of clinical, laboratory and diagnostic parameters that often are inadequately defined as to the methods involved in determining each. The reliability of clinical methods, data and judgements has recently been reviewed by Koran.[48] The findings of this review should debase much physician confidence in our ability to agree on clinical signs, laboratory interpretation and diagnoses. It was found that the more physicians participating in the study of any one population, the more diagnostic categories there were to be considered and that inter-observer

agreement was found to fall with less severe degrees of abnormality. Secondly, it was noted that inter-observer agreement increased with the degree of normality in a given population and agreement on normality was found to be more frequent than agreement on abnormality. It was also found that pairs of physicians with a higher level of training for a given task will agree more commonly than those with less sufficient training. Lastly, with prior agreement by a physician observer group on definitions, decision rules, criteria, etc., involving quantitative data (versus qualitative) inter-observer agreement improved. What is thus needed before studying any population is prior agreement amongst the observer group on terminology, criteria and data to be collected. This agreement and understanding should extend to all members of the team performing the study.

With perfect inter-observer reliability probably unattainable,[48] the definitions of procedures, diagnoses, clinical and laboratory parameters to be measured should be chosen and defined to minimize possible observer variation. Perhaps the most fundamental parameters that can be measured are the anatomical diagnoses and with complete information the degree of observer variation should be small. This fact lends itself well to the trauma patient in that in a large proportion of victims the anatomical pathology is either directly or indirectly visualized, leaving little room for disagreement. The development of severity indices has led to a broad classification of these indices into anatomical indices, based on the anatomical diagnosis, and clinical indices, which are based on a variety of clinical parameters. As will be discussed below each type has a very different role in the evaluation of health care delivery.

3.2 The Abbreviated Injury Scale

The first attempt to classify injuries on a scale of severity was made by DeHaven at Cornell University in 1943.[26] These efforts were directed at victims of airplane crashes. In the ensuing years, efforts at standardizing diagnostic codes persisted and this ultimately led to the International Statistical Classification of Diseases, Injuries and Causes of Death. While not usuable in severity rating, its primary purpose was to identify diseases and injury by a three to four digit code. This could then be used to develop incidence data.[26]

In 1971 the American Medical Association Committee on Medical Aspects of Automotive Safety published the Abbreviated Injury Scale.[26] This scale was published in an attempt to reduce the amount of subjectivity in determining injury severity. The threat to life was subjectively evaluated by the committee and a numerical score, from zero to nine, was assigned to each of the trauma diagnoses in the International Classification of Diseases Code. The authors realized that subjectivity could not be completely eliminated and the diagnostic code was far from being able to describe all injuries, however it was proposed to at least minimize subjectivity and to form the basis for the evolution of a more refined scale.

In the Abbreviated Injury Scale the severity category of zero is defined as no injury. Category 1 implies minor injury such as abrasion, minor laceration, minor sprain, etc. Category 2 includes moderate injury such as undisplaced long bone fractures, large lacerations and loss of consciousness for less than fifteen minutes. Category 3 is for severe injuries but not life threatening and category 4 is for injuries

that are so severe they do pose a threat to survival. An example of category 3 would be open fractures of a long bone with nerve or vessel involvement, while category 4 includes such injuries as flail chest and rupture of the spleen. Category 5 is reserved for those injuries that are so critical that survival is uncertain. Examples of such injuries are aortic laceration, avulsion or severe laceration of intra-abdominal organs and/or vessels, and cerebral injury with unconsciousness of more than twenty-four hours. Categories 6 through 9 deal with an injury or injuries that are invariably fatal and the time of death following such a massive injury.[26]

The Abbreviated Injury Scale thus reflects the severity of tissue damage in one numerical value. It does not attempt to identify and separate the various criteria used in arriving at that value. The scale is intended for use in all types of research and is not necessarily limited to medical research. Physicians rate the severity of an injury on the basis of threat to life, impairment and length of treatment while automotive engineers for example, are more interested in the amount of energy required to produce a given injury. All of these factors have been considered by the committee in deriving the Abbreviated Injury Scale.[26,27]

3.3 <u>The Comprehensive Injury Scale</u>

In 1972, the American Medical Association Committee on Medical Aspects of Automotive Safety published the Comprehensive Injury Scale as an extension of the Abbreviated Injury Scale.[27] In this scale there are five components of each injury that are identified and rated numerically from one to five. The first category is energy dissipation which refers

to the force required to cause a given injury on impact of the occupant with the inside of his car (or the ground). Much of the information on this subject has been obtained from animal and cadaver studies and although not purely objective, much of the subjectivity has been removed by these experiments. The second category is that of threat to life, which as indicated above is a subjective ranking except in those injuries that are invariably fatal. Because of this subjectivity the ranking may not hold for any given individual but as an average it is much more reliable. The third category is that of permanent impairment which is defined as "any anatomic or functional abnormality or loss after maximal medical rehabilitation has been achieved".[27] This definition is intended to reflect impairment as a direct relation to the severity of the injury. Disability is defined as the reduction or elimination of "ability to engage in gainful activity".[27] By this definition disability reflects many other factors including attitude, economic and social environment, and occupation. The fourth category of the comprehensive scale is the treatment period. This reflects the severity of the injury and not the severity of the crash, as some minor injuries in terms of energy dissipated, may require a long treatment period. The last category is incidence. Although it may appear to be a purely satistical rating it is included by the committee to identify specific problems that occur in automobile crashes. An example cited is the high incidence of major chest wall injuries that ultimately led to the design of the energy absorbing steering wheel column. The Comprehensive Injury Scale is intended for researchers of all backgrounds and thus identifies not just the anatomical defect but what was required to produce that injury, how often the injury occurs,

what is required for treatment time and what functional result to be expected after medical rehabilitation.

The development of the Abbreviated and Comprehensive Injury Scales satisfied a fundamental need within the medical community that enabled comparison of groups of patients with a particular injury but of differing severities. While the comparison of groups with similar injuries may be the best approach when trying to compare treatment protocols, it is not feasible in the majority of accident victims because in the more severe accidents there is usually more than one injury per patient. Neither of these two injury scales takes into account the effect that one injury will have on the other.

3.4 The Injury Severity Score

Because of the interrelationship of each injury in the multiple trauma victim, there existed a need to be able to describe the patient with multiple injuries, if adequate evaluation and comparison of morbidity and mortality in this group of patients was to be made. One of the first attempts at developing such a method was proposed by Baker et al[4] in 1974. Their method, the Injury Severity Score, resulted from analyzing the Abbreviated Injury Scale's correlation with mortality and by simply adjusting it for patients with more than one injury.

The Injury Severity Score is based on the one or more anatomical diagnoses of each patient and the respective Abbreviated Injury Scale value for each diagnosis. The authors[4] used only Abbreviated Injury Scale values one to five and the injuries were all coded as if the outcomes were not known. Each injury with its code was categorized by body region, of

which there were six. These six regions are: head and neck, chest, abdominal and pelvic contents, extremities including the pelvic girdle and general. Each region of the body was then graded by severity and only the most severe injury from a given region was considered. The study population consisted of 2200 victims of motor vehicle accidents treated at eight Baltimore hospitals over the period 1968-1969.

In this study it was found that the relationship of the Abbreviated Injury Scale to mortality was non-linear. The addition of a second injury widely affected the outcome such that one injury with a scale of 5, had a mortality ranging from 22% to 100% depending on the severity of the second injury. The authors of the Abbreviated Injury Scale had cautioned against adding or averaging the values and it was stated that the "quantitative relationship of the Abbreviated Injury Scale codes is not known and is almost certainly non-linear".[4] Indeed this was shown in the study by Baker et al and led to a simple adjustment that would enable comparison of individuals with more than one injury.

The authors[4] chose a quadratic function to arrive at a score that would allow comparison of different injuries. By squaring the Abbreviated Injury Scale value, it was found that an individual whose injury was worth a 5 had the same mortality as another individual with two injuries valued at 4 and 3. Each ended up with the same score, the sum of the squares is equal to 25 in both cases, and the mortalities of 22% and 24% respectively were similar. If the third most severely injured region was added, mortality was also influenced and by squaring the value of each of the three regions before adding them together, correlation between the total injury severity score and mortality was further improved. Addition

of the fourth most severely injured region however, did not significantly change the correlation with mortality. An example of the calculation of the Injury Severity Score as defined by the authors is given in Table 1.

Having found the correlation of the Injury Severity Score with mortality the authors turned their attention to other parameters. It was found that for different age groups, separate relationships of mortality with the Injury Severity Score existed (Fig. 4). The age-associated increase in mortality for a given score is perhaps expected, but it was found that this increase was especially pronounced for less severe injuries. Further examination of the records of those that died indicated that the higher the Injury Severity Score, the shorter the interval between the time of the accident and the death of the victim. Analysis of the survivors with a similar Injury Severity Score, revealed that survival was not influenced by race or sex, or by whether the victim was inside the car or a pedestrian. In their concluding remarks the authors point out that those patients with a score less than 10 rarely die, while those with a score greater than 50 rarely survive. The authors go on to express their hope that the Injury Severity Score will be most beneficially used to identify those patients who are "sick enough to be adversely affected by poor care, but not so sick that they will not survive even with optimum care".[4]

3.5 Utility of the Injury Severity Score

Since its original description[4] the Injury Severity Score has received independent confirmation[17,65] and its utilization by various

TABLE 1

Calculation of the Injury Severity Score

I. Assign abbreviated injury scale to each anatomical diagnosis

II. Classify diagnoses by body region - head and spine, thorax, abdomen, face, extremities and pelvis, general.

III. Determine the three highest abbreviated injury scale values from different body regions, square these three values then add them to get the Injury Severity Score.

			AIS		$(AIS)^2$
Example:	Thorax:	flail chest	4	=	16
		contused lung	3		
	Abdomen:	ruptured spleen	4	=	16
		contused small bowel	3		
	Extremities:	fractured femur	3	=	9
		fractured humerus	2		
		Injury Severity Score	=		41

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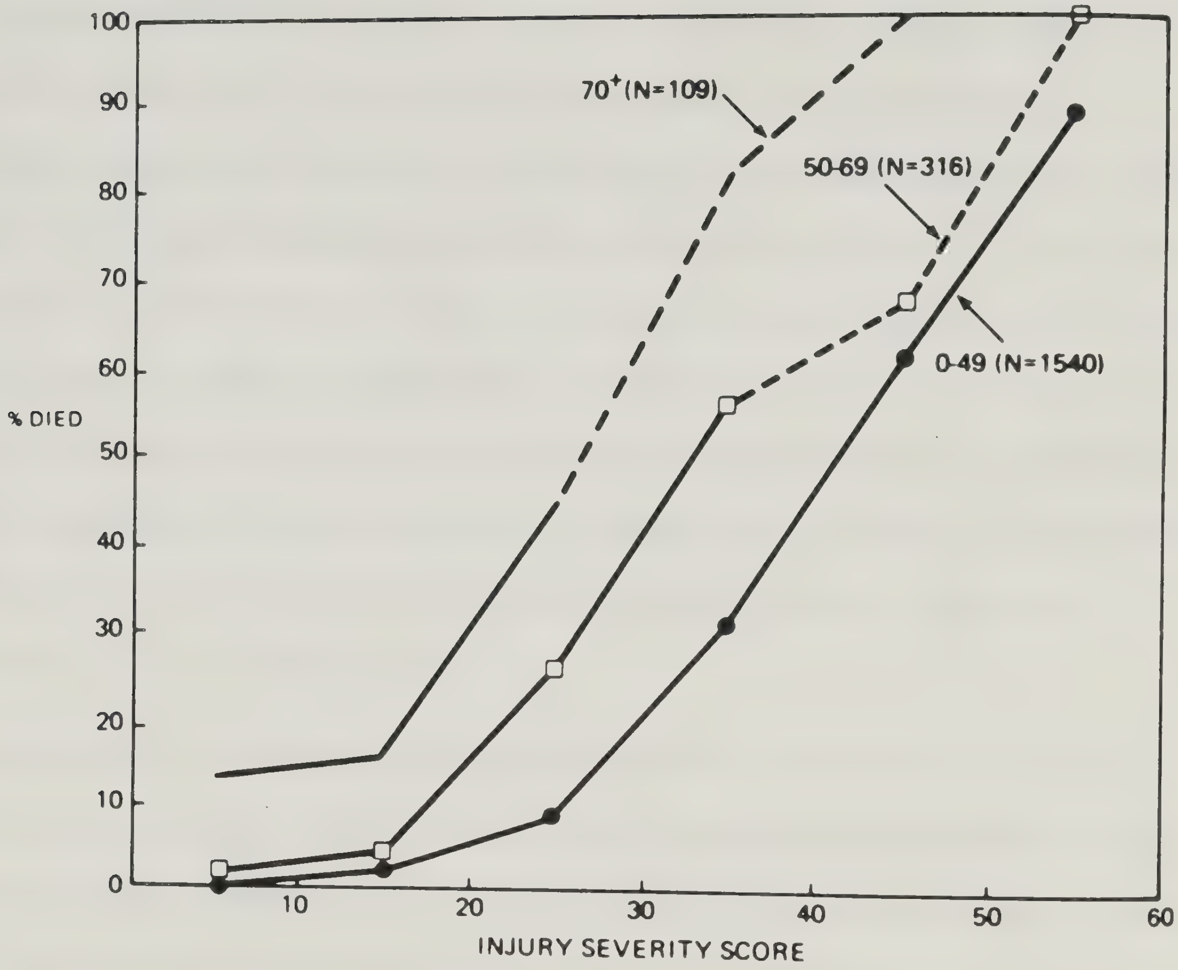
Figure 4



From: Baker, S.P. et al - "Injury Severity Score: A Method for Describing Patients with Multiple Injuries and Evaluating Emergency Care"
J. Trauma Vol.14 no.3 p.192, 1974

authors[5,17,21,40,52,60,65,70,77] has served to define its role in the statistical portrayal of the accident victim. The fact that the Injury Severity Score correlates with mortality in the blunt trauma victim is well established[5,17,65] however, it does not correlate with mortality in penetrating injuries[57] and has not been applied to any large study group with penetrating injuries. Additionally, the Injury Severity Score has been tested as an index of morbidity by various authors[17,65] and it was found to correlate with major surgical procedures, length of stay in hospital and the disability incurred. Other authors[60,70] have tested the relationship of the Injury Severity Score with biochemical parameters that are characteristically abnormal in the stressed patient. Correlation with serum levels of cortisol, lactate, pyruvate, alanine and ketone bodies were shown in these studies.

Perhaps most importantly and as its authors' intended, the Injury Severity Score has over the past three years, been used in studies that are attempting to evaluate the care of the multiple trauma patient. West et al[77] studied two systems of care by comparing the Injury Severity Scores of patients that died in motor vehicle accidents in two counties in California. The reason for the comparison of these particular counties, Orange County and San Francisco County, was to compare a regional trauma unit system of care (San Francisco County) against a less organized and defined method of care (Orange County). It was found that the average Injury Severity Score in non-CNS related deaths was significantly greater in San Francisco County than in Orange County, leading the authors to conclude on this and other grounds, that the type of care offered by the trauma unit in San Francisco County was superior. Other studies have

since appeared where in addition to the mean Injury Severity Scores as a measure of the magnitude of injuries causing death, the mean Injury Severity Scores for morbidity and for successful rehabilitation have been published.[40,55]

A further role for the Injury Severity Score has recently been proposed by Champion et al,[21] who have incorporated it into a combined index. This proposed index includes the Trauma Score, a clinical index of severity useful in patient triage,[21,22] the Injury Severity Score and the patient's age. The authors have tested the validity of this proposed index mathematically but it has yet to be proven in clinical use. A more detailed description of the Trauma Score is undertaken in the pages that follow.

3.6 Criticisms of the Injury Severity Score

In keeping with the scientific world, a new method or technique must withstand critical evaluation and prove its usefulness in many trials before becoming universally accepted. As indicated above, the Injury Severity Score's applications have been generally accepted within the research community and further definition of its precise role is ongoing. It has however met with some critics, as any new technique should, and these criticisms are worth examining for their validity.

The Injury Severity Score is criticized because of a high degree of subjectivity incorporated into it by using the Abbreviated Injury Scale as its basis.[23] As was indicated earlier, the Abbreviated Injury Scale attempts to lump threat to life, impairment, treatment period, energy dissipated and incidence, into its one numerical score. The subjectivity

enters into this calculation primarily because of the estimation of a given injury's threat to life. An alternative proposal is to base the score on observed probabilities of death for a given injury, however analyses of both these methods show no significant difference in the misclassification rate.[23]

Another criticism leveled at the Injury Severity Score also relates to its foundation on the Abbreviated Injury Scale. The mechanics of working with the Abbreviated Injury Scale and applying it to the International Classification of Disease Code, has revealed the process to be time consuming and the accuracy to rely on the ability of the medical records coder to attach the proper diagnostic code to a given condition. In addition the International Classification of Diseases codes do not describe every conceivable diagnosis and leave a certain number of conditions to the "unspecified" category.[35] This is not a problem unique to the Injury Severity Score in that any index based on a diagnostic coding system relies not only on the accuracy applied by the medical records coder, but also on the accuracy of the information supplied by the treating physician.

A third major criticism of the Injury Severity Score arises on the mathematical grounds that it violates certain principles of indices of severity. This argument is presented by Krischer,[49,50] but it is also supported by others.[19,21,23] The criticism is made that in the calculation of the Injury Severity Score it is possible, with a combination of moderately severe injuries, to attain a higher score than if only one fatal injury existed. Therefore, the injury severity score violates the principle of an ordinal scale. An additional problem related to the calcu-

lation of the injury severity score is that only a finite set of forty-four noncontinuous values can be calculated, with a range of zero to seventy-five. Furthermore, the intervals at the upper end of the scale are large such that between the scores sixty and seventy-five, only two possible scores exist. Because of this Krischer feels that the correlation between the Injury Severity Score and mortality results from statistical artifacts associated with the construction of the index itself.

In reply, the original authors of the Injury Severity Score[59] point out that in a perfect index incorrect ranking should not exist. They readily admit that their index may allow for some incorrect rankings but the important fact is to learn how often these occur and to make adjustments as they become necessary. As with any statistical ranking that incorporates a certain amount of averaging, the outcome of any one situation may not exactly follow the behaviour of the group as a whole. The degree to which this variation from the mean occurs will affect the predictive value of the index, but knowing this fact allows for a more accurate assessment of the individual patient. Furthermore, the authors refute the claim that the Injury Severity Score is not an ordinal scale, as they correctly point out that in numerous clinical studies it has been demonstrated that the higher the Injury Severity Score the higher the mortality. They contend that because it is an ordinal scale and not an interval scale, the lack of continuity within the scale is irrelevant.

3.7 The Anatomical Indices of Severity

Understanding how an index of severity is constructed will allow for its proper utilization. Because the Injury Severity Score is based on the anatomical diagnosis it relies on correct and complete information

about each patient. This information is often not forthcoming until some time after the injury occurred, indeed in some situations not until an autopsy has been performed. It thus falls under the broad classification of an anatomical index as opposed to a clinical index, and it therefore must be used as such. The primary role of the anatomical indices is in epidemiological studies and comparative evaluation of emergency care programs.[19] Although other severity indices of this type have been proposed,[23,29] and indeed the Abbreviated and Comprehensive Injury Scales must be included in this group, the Injury Severity Score has become accepted as the standard within the field of clinical research on the multiple trauma victim.[19]

3.8 The Clinical Indices of Severity

The clinical indices are so named because they are based on clinical parameters assessed by medical or paramedical personnel. These indices are promoted primarily as triage indices for use at the scene of the accident or in the emergency room. They are a means of describing the patient's clinical status at that particular point in time so that appropriate and rapid decisions on therapeutic interventions can be made. Their value in predicting longterm outcome is somewhat limited because the initial assessment must often be made with incomplete information.

The first such clinically based index was developed in 1971 and used five parameters, each with four categories of severity. A subsequent modification for use in the prehospital setting by non-physicians did not overcome the main limitation to its validity, namely the need for subjective judgements that do not satisfy reliability criteria.[19]

Further efforts in this area continued in attempts to eliminate as much as possible subjective judgements and to concentrate on parameters that were easily measured with high predictive value. As previously indicated, much of the work in this area has been done by Champion et al[21,22,23] and has led recently to the development of the Trauma Score,[21] a modification of the Triage Index,[22] described in 1980. (Table 2). This score is based on five parameters that are individually weighted with regard to their respective values. Because early death of the trauma victim is usually due to respiratory, cranial or hypovolemic causes, the five parameters used are based on these three body functions. The first two parameters are respiratory rate and respiratory effort. The two cardiovascular parameters to be measured are systolic blood pressure and capillary refill. The last parameter measured is the Glasgow Coma Scale[71] which is of proven clinical value in assessing a patient with a head injury. The Trauma Score is a continuous scale from one to sixteen, with the higher value representing the normal. It is suggested that a score of 12 or less represents a potentially critical injury and that these patients must be aggressively managed. Because the trauma score is such a recent addition, its applicability and validity have yet to be independently tested and reported on.

3.9 Indices of Severity Unrelated to Trauma

Other indices that can be used in different medical settings than trauma are in existence. The Coronary Prognostic Index[61] is based on age, sex, previous history of heart disease, presence of shock and cardiac failure, and on the electrocardiogram. The index is a continuous ordinal scale of one to twenty-eight with mortality increasing as the index value

TABLE 2

Calculation of the Trauma Score

		Value	Points	Score
A. Respiratory Rate:		10-24	4	
		25-35	3	
		>35	2	
		<10	1	
		0	0	A______
B. Respiratory Effort:		Normal	1	
		Shallow or Retractive		B______
C. Systolic Blood Pressure:		>90	4	
	Systolic cuff pressure	70-90	3	
		50-69	2	
		<50	1	
	No carotid pulse	0	0	C______
D. Capillary Refill:				
forehead, lip mucosa, nailbed				
	Normal	< 2 sec	2	
	Delayed	> 2 sec	1	
	None		0	D______

Table 2 continued on next page...

Table 2 continued ....

E. Glasgow Coma Scale		Total GCS Points	Score	Score
1. Eye opening				
spontaneous	... 4	14-15	5	
to voice	... 3	11-13	4	
to pain	... 2	8-10	3	
none	... 1	5- 7	2	
		3- 4	1	E______
2. Verbal Response				
oriented	... 5			
confused	... 4			
inappropriate	... 3			
incomprehensive	... 2			
none	... 1			
3. Motor Response				
obeys commands	... 6			
purposeful (pain)	... 5			
withdrawn	... 4			
flexion	... 3			
extension	... 2			
none	... 1			

Total G.C.S. (1 + 2 + 3) = ______

Trauma Score (total points A + B + C + D + E) = ______

rises. The CHOP Index[19] is intended for use in the clinical setting relating to internal medicine. It is based on the serum osmolality, creatinine, hematocrit and systolic blood pressure. It is defined as the square root of the sums of squares of the deviation from the normal average value of each variable. It is an ordinal scale. The Cumulative Illness Rating Scale[53] is categorized as a rehabilitation outcome index and is based on the level of impairment of six major organ systems. Each organ system is divided into components so that a total of thirteen components exist. These are then individually rated as to degree of impairment from zero to four. The scale is a continuous ordinal scale with scores of zero to forty-two.

These latter indices all suit the criteria of a severity index and are acceptable methodologically. They are not however, based on data that is routinely collected in pre-hospital or routine in hospital investigations. Therefore, their use in these settings is limited and they should be restricted to situations where the data is collected specifically for calculation of the index.[19]

CHAPTER 4 STUDY METHODS AND RESULTS

4.1 Methods

As stated in the introduction, the goal of the research project was to quantitatively and qualitatively evaluate the multiple trauma patient population at the University of Alberta Hospital. Being a tertiary care center for northern and central Alberta, this hospital was thought to have a sufficient volume of trauma to allow for an adequate sample. As well, the hospital's Intensive Care Unit operates an air ambulance service for critically ill or injured patients in Northern Alberta and British Columbia, the Yukon and the Northwest Territories.

Because it was necessary to design the study, collect the data, calculate the results and write a thesis within a twelve month period, it was decided that a retrospective study would be most appropriate. Retrospective studies are limited by certain constraints. First, the information to be obtained is not necessarily recorded as an event. It must be sought out from the voluminous medical records and is often entered into discharge summaries or operative reports by a second hand observer and therefore its accuracy may be open to question. Where large volumes of charts are reviewed, one relies on summaries and printouts prepared by medical record technicians. This also is a situation where the data is recorded by someone removed from the particular case and may introduce errors. Second, the researcher working on the chart review and attempting to answer a specific question can introduce a bias in that he is probably not an impartial observer. Finally, while many records are complate, there is often a significant percentage that are not. This missing information

may be irretrievable.

The calendar year 1979 was chosen as the period to be studied. Within the hospital medical records department it represented the most recent year for which the charts were completed and summarized.

The University of Alberta Hospital participates in the Professional Activity Study (P.A.S.) and so all of its medical records are summarized and stored by the P.A.S. computer in Ann Arbor, Michigan. This ongoing study is run by the Commission on Professional and Hospital Activities, an American organization. By being a part of this study, the hospital is provided with summaries of its medical records covering a variety of parameters. These summaries are provided for six month intervals and are listed by the diagnostic code. The code used is the International Classification of Diseases (I.C.D.-9-C.M.). In addition to the diagnoses (all are listed), the summary lists operative procedures, days in an intensive care unit, type of admission, admission hour, consultations, disposition, age, sex and hospital service at discharge. This provided an adequate data base to initiate a chart review.

A review of all patients with a diagnosis of trauma (ICD-9-CM 800.00 to 959.9) was made. The injury severity score for each patient was calculated. The study was intended for the more seriously injured multiple trauma patient and so the inclusion criterion was defined as any patient with an Injury Severity Score of greater than ten. A more thorough review of a smaller number of more seriously ill patients was then achievable. It was hoped that in concentrating on this group of injured patients it would be possible to identify those patients that were sick enough to be adversely affected by improper care.

For each patient a questionnaire was completed. (Appendix I). The data recorded related to demographic categorization i.e. age, sex. Hospital data retrieved included type of admission (i.e. emergency, readmission, etc.) month of admission and discharge, hospital service, days in hospital, days in an intensive care unit, attending physician and if a consultation was made. The individual diagnoses were recorded and assigned the correct Abbreviated Injury Scale value so that the Injury Severity Score of each patient could be entered. The diagnosis was checked by reviewing the history of admission, discharge summary, operative reports and where available, autopsy findings. Each patient was classified as to the type of injury i.e. blunt or penetrating. Additionally, the location of the accident and all operative procedures were recorded.

With regard to disposition a variety of outcomes were recorded. For those that died, operating room and emergency room deaths were identified, as were post-operative deaths and coroner's cases. For those patients leaving hospital alive, it was noted whether they were sent home or to an intermediate facility.

Having recorded all of the information, the computation of results was then undertaken. The age range, mean age and median age were calculated. The patients were then classified into groups according to the Injury Severity Score. To allow for comparison with other studies similar groupings were used i.e. 11-19, 20-29, 30-39, 40-49 etc. For each group the mortality, average number of surgical procedures and average number of days in hospital was calculated. Using the least squares method, functions of the Injury Severity Score versus mortality, days in hospital and number of surgical procedures were plotted. Correlation coefficients were also

calculated. Additionally, the average Injury Severity Score by month of admission was derived and tabulated.

In working with the raw data it became apparent that there was a large subset of patients with head and spine injuries. The mortality of this subset was calculated and the month of admission was tabulated. Comparison of the mortality rate of this group of patients with the mortality rate of other types of injuries with the same Injury Severity Score was made using the Chi-square test.

The data was then regrouped according to the site of the accident. Three groups were defined. These were urban, meaning metropolitan Edmonton; rural, within 150 kilometers of Edmonton; and rural, greater than 150 kilometers from Edmonton. The average Injury Severity Score and mortality of each group was calculated. Comparisons of the mortalities of these groups were made using the Chi-square test.

Lastly, those patients that died were classified into CNS and non-CNS related deaths. The average Injury Severity Score of each group was calculated. Those patients that died in the emergency room of causes related to trauma during 1979 were also included. The records of this group were obtained from the Office of the Medical Examiner of Alberta.

All of the organization and the calculations of results was done manually and with the aid of a desk top calculator. Although the patient questionnaire has all of the information recorded numerically for entry into a computer, the information has not been entered into a data bank at this point in time. The decision to do the calculations manually was based on financial constraints.

4.2 Results

During the period from January 1, 1979 to December 31, 1979 there were 2186 patients discharged from the University of Alberta Hospital with a diagnosis of trauma. The Injury Severity Score was calculated for each patient. There were 384 patients with scores greater than ten, of these the charts were retrieved on 381. Because the Injury Severity Score is known to correlate with mortality in blunt trauma only, for the purposes of the study only those patients with blunt trauma were thoroughly reviewed. Of the group of patients with Injury Severity Scores greater than ten, 353 were classified as being secondary to blunt trauma (92 percent).

The age distribution of this group of patients was characteristic of other groups of trauma patients. The mean age was twenty-nine years and the median age was 23 years. The range spanned an interval of two months to eigthy-nine years of age. (Fig. 5). The sex ratio was 2:1, male to female. The overall mortality was 13.3 percent.

The accidents causing the various injuries in this patient population, occurred within the city of Edmonton in 115 cases (thirty-three percent of the total). The city was defined as Edmonton, St. Albert, Fort Saskatchewan and Sherwood Park. The mortality of this group was 13 percent and the average Injury Severity Score was 22.6. (Table 3).

Of the two hundred thirty-six patients injured outside of the city, ninety-nine (28 percent of the total) were injured within 150 kilometers of Edmonton. The mortality of this group was 8.1 percent and the average Injury Severity Score was 24.4.

Figure 5

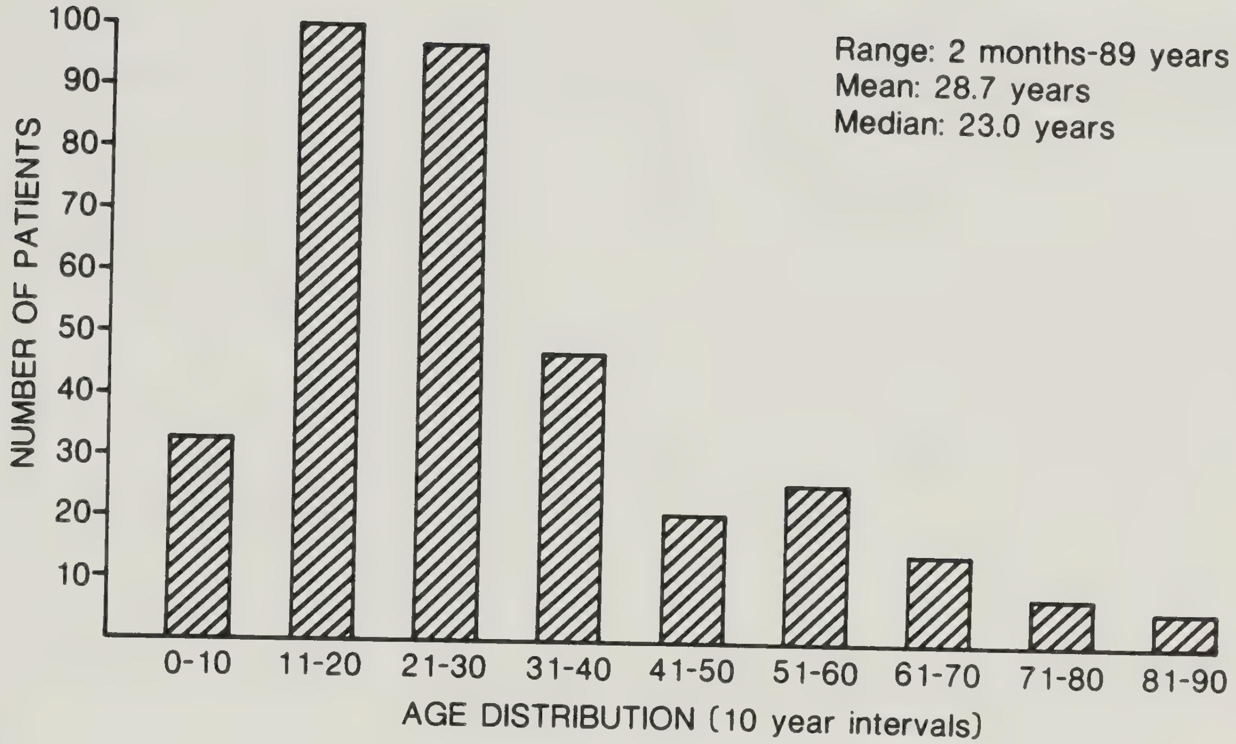

Range: 2 months-89 years
Mean: 28.7 years
Median: 23.0 years
NUMBER OF PATIENTS
100
90
80
70
60
50
40
30
20
10
0-10
11-20
21-30
31-40
41-50
51-60
61-70
71-80
81-90
AGE DISTRIBUTION (10 year intervals)

TABLE 3

Location of Accidents

	Number of Patients	Average Injury Severity Score	Mortality %
Edmonton	115	22.6	13.0
Rural (Total)	236	23.9	13.6
Rural (within 150 km of Edmonton)	99	24.4	8.1*
Rural (greater than 150 km from Edmonton)	127	23.8	17.5*

* χ^2, $p < 0.05$

The remaining patients (one hundred thirty-seven, 39 percent of the total) came from distances greater than 150 kilometers away. These distances ranged up to 2000 kilometers. The more active referral centers were Grande Prairie (50 patients), Red Deer (25 patients), Fort McMurray (11 patients), Lloydminster (10 patients) and Hay River/Yellowknife (9 patients). The mortality of this group was 17.5 percent and the average Injury Severity Score was 23.8.

In comparing the average Injury Severity Score of these three groups, no statistically significant difference exists. Comparison of the mortality rate of the three groups does reveal some variation. The mortality rate of the city patients is not different from that of the rural group as whole, or from the mortality rate of the two subsets of rural patients. However, the mortality of 17.5 percent in the rural patients originating from greater than 150 kilometers from Edmonton, is significantly greater than the 8.1 percent mortality of those patients coming from within 150 kilometers of the city (χ^2, $p < 0.05$).

The total group was also classified by Injury Severity Score (Table 4). This distribution is similar to other series.[17,65] This study population was characterized by a large subset of isolated neurological injuries of which there were a total of 138 patients. Because of the derivation of the Injury Severity Score, a maximum value of twenty-five exists in a single system injury. For this reason, this subset of patients is confined to the Injury Severity Score groupings eleven to nineteen and twenty to twenty-nine. This fact will be emphasized below, as it affects the relationship between the Injury Severity Score and mortality.

Admissions by month of the year are shown in Fig. 6. Because of

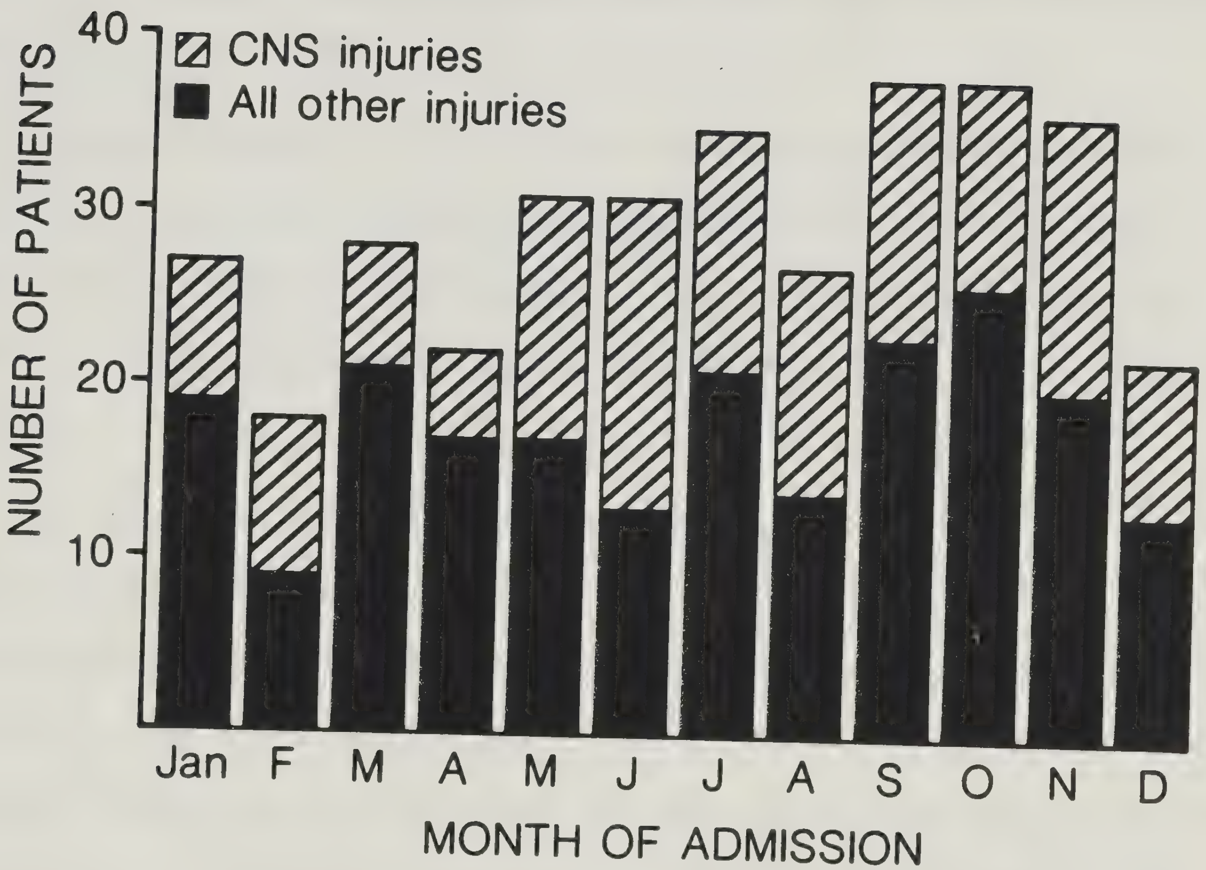
TABLE 4

Distribution of Patients by the

Injury Severity Score

Injury Severity Score	Number of Patients
11 - 19	123
20 - 29	182
30 - 39	30
40 - 49	10
50 - 59	8

Figure 6


40
30
20
10
NUMBER OF PATIENTS
CNS injuries
All other injuries
Jan F M A M J J A S O N D
MONTH OF ADMISSION

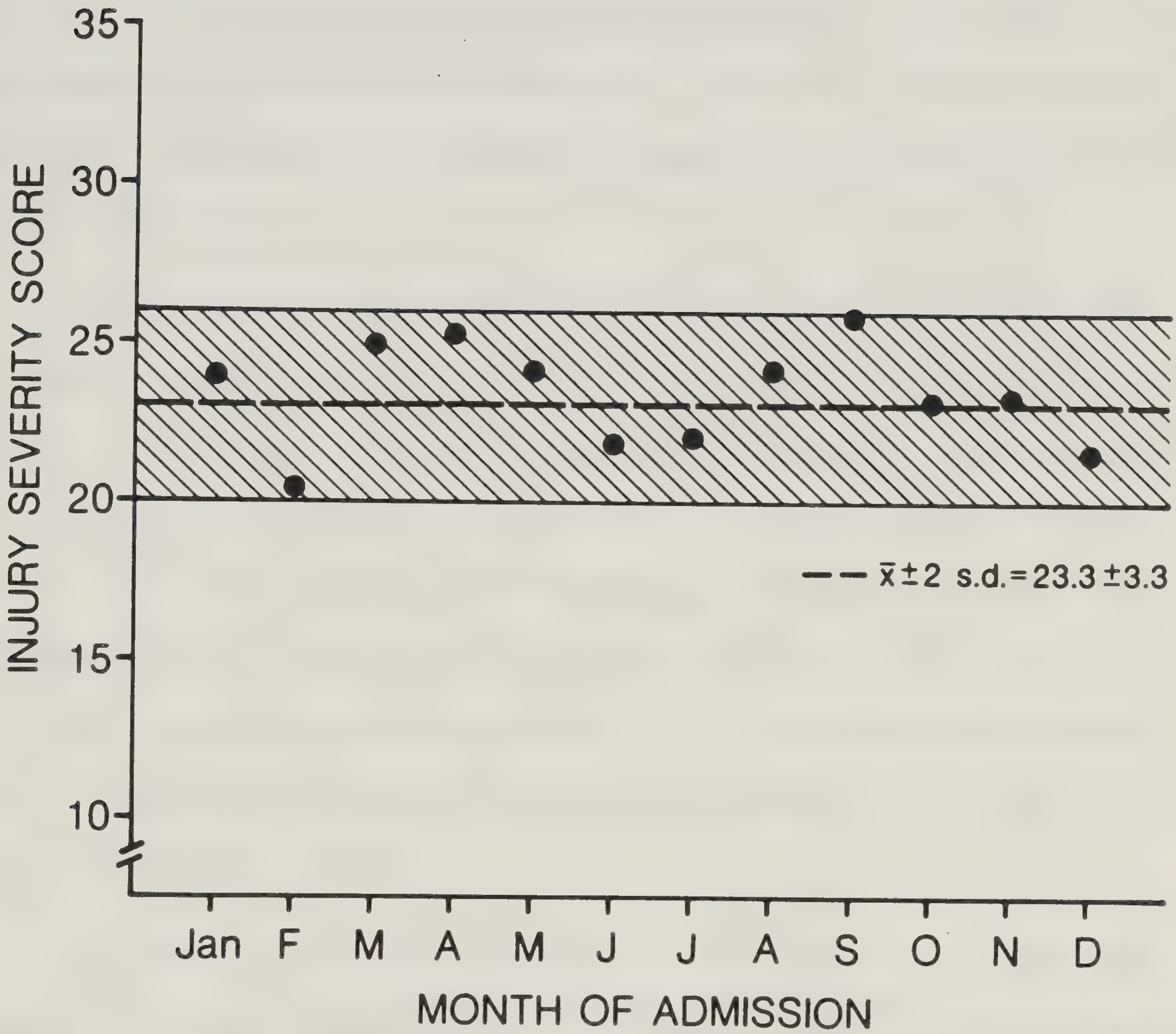
extreme seasonal weather variations and many seasonal jobs and hobbies, it was of interest that minimal variation in the number of admissions per month existed. The peak months for total admissions were September and October, 38 patients in each. All of the monthly totals fell within two standard deviations of the mean. ($\bar{x} \pm 2$ s.d. $= 29 \pm 13.2$). A similar pattern emerged with regard to neurological admissions. The peak month was June, but once again the monthly admissions were within two standard deviations of the mean. ($\bar{x} \pm$ s.d. $= 12 \pm 8.0$).

As an additional test of seasonal variation, the average Injury Severity Score of the trauma patient admissions was plotted by month (Fig. 7). Once again no significant monthly variation was found, all lying within two standard deviations of the mean. ($\bar{x} \pm 2$ s.d. $= 23.3 \pm 3.3$).

As previously explained, the Injury Severity Score is based on the Abbreviated Injury Scale. This scale is a numerical value from one to five based on threat to life, energy dissipated, degree of impairment and treatment time for a given injury.[26] It stands to reason that the Injury Severity Score should also reflect this make-up and therefore be useful as an index of morbidity as defined by length of stay in hospital and surgical procedures performed.

To test this hypothesis, the injury severity score was plotted against the length of hospital stay. For this study, acute care was defined as up to fifty days or the point of discharge. The discharge included discharge home or to an intermediate care facility. Any patient requiring longer than fifty days was excluded as were all patients that

Figure 7



35
30
25
20
15
10
INJURY SEVERITY SCORE
— — x̄ ± 2 s.d. = 23.3 ± 3.3
Jan F M A M J J A S O N D
MONTH OF ADMISSION

died. A linear relationship was found (Fig. 8) with a high degree of correlation (r = 0.98).

A similar relationship was found between the Injury Severity Score and the number of surgical procedures performed. Only the surviving patients were included in deriving this function. This linear relationship (Fig. 9) also has a high degree of correlation (r = 0.97). Surgical procedures include all major surgery i.e. laparotomy, thoracotomy etc. and also minor procedures i.e. peritoneal lavage, tube thoracostomy, blood transfusion, etc.

If the Injury Severity Score is to be applicable as a tool for evaluating health care delivery, its correlation with the outcome of the patient is important. The most finite outcome measure is death, and the Injury Severity Score has been shown by its original authors[4,5] and others[17,65,70] to correlate with mortality. The data from this study revealed a similar correlation of mortality with the Injury Severity Score (Fig. 10). The degree of correlation (r = 0.91) is high and when the curve is compared with the original curve by Baker et al,[4] similarities are seen to exist. (Fig. 4).

This study's population is unique in that there are a very large number of isolated head and spinal injuries (n = 138). As stated earlier, the maximum Injury Severity Score that a single system injury can attain is twenty-five. Because this large group is confirmed to a maximum score of twenty-five, the increased mortality from head and spinal injuries distorts the mortality for all patients with scores of twenty to twenty-nine. When this group of patients (n = 182) is broken down into isolated

Figure 8

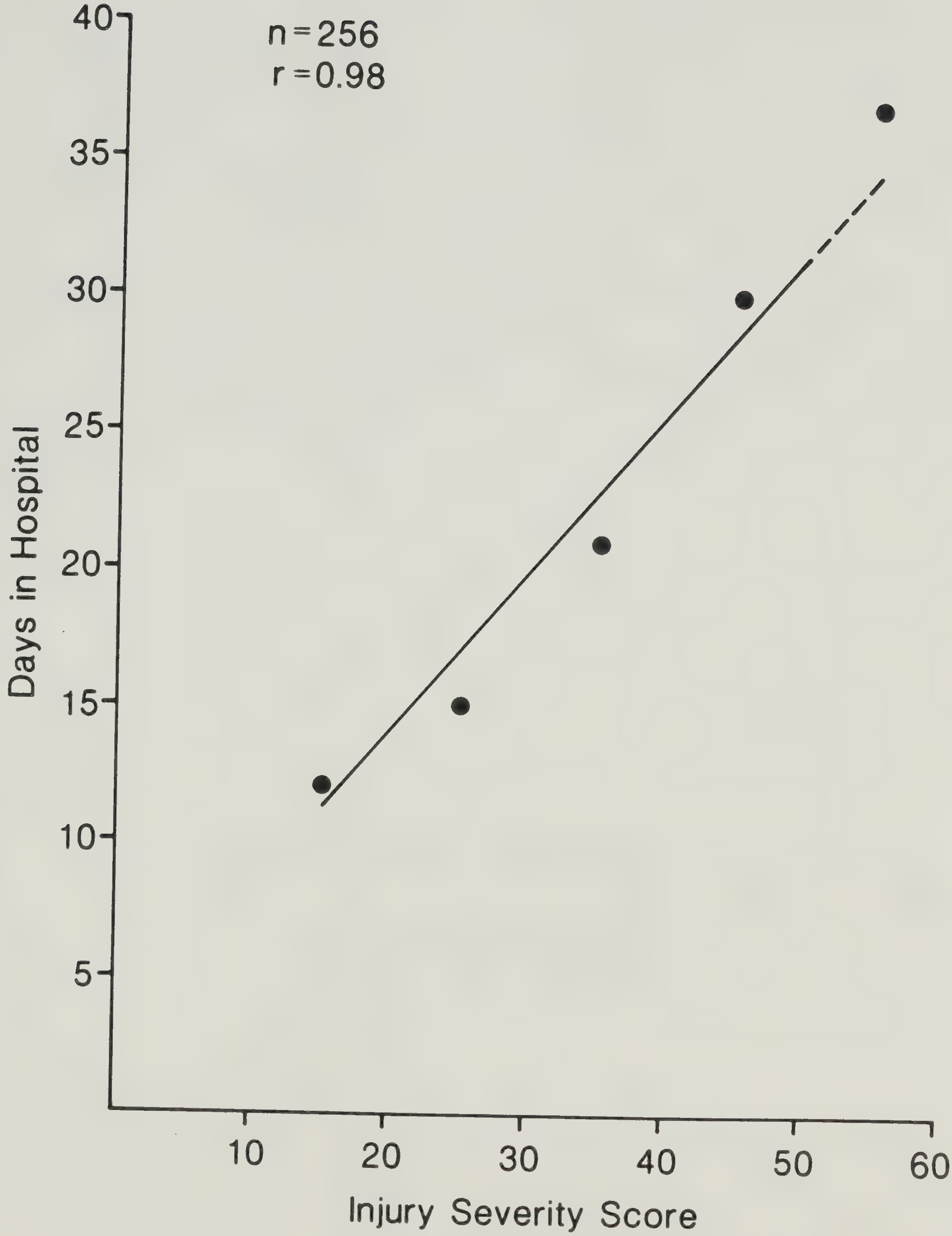

n=256
r=0.98
Days in Hospital
40
35
30
25
20
15
10
5
10
20
30
40
50
60
Injury Severity Score

Figure 9

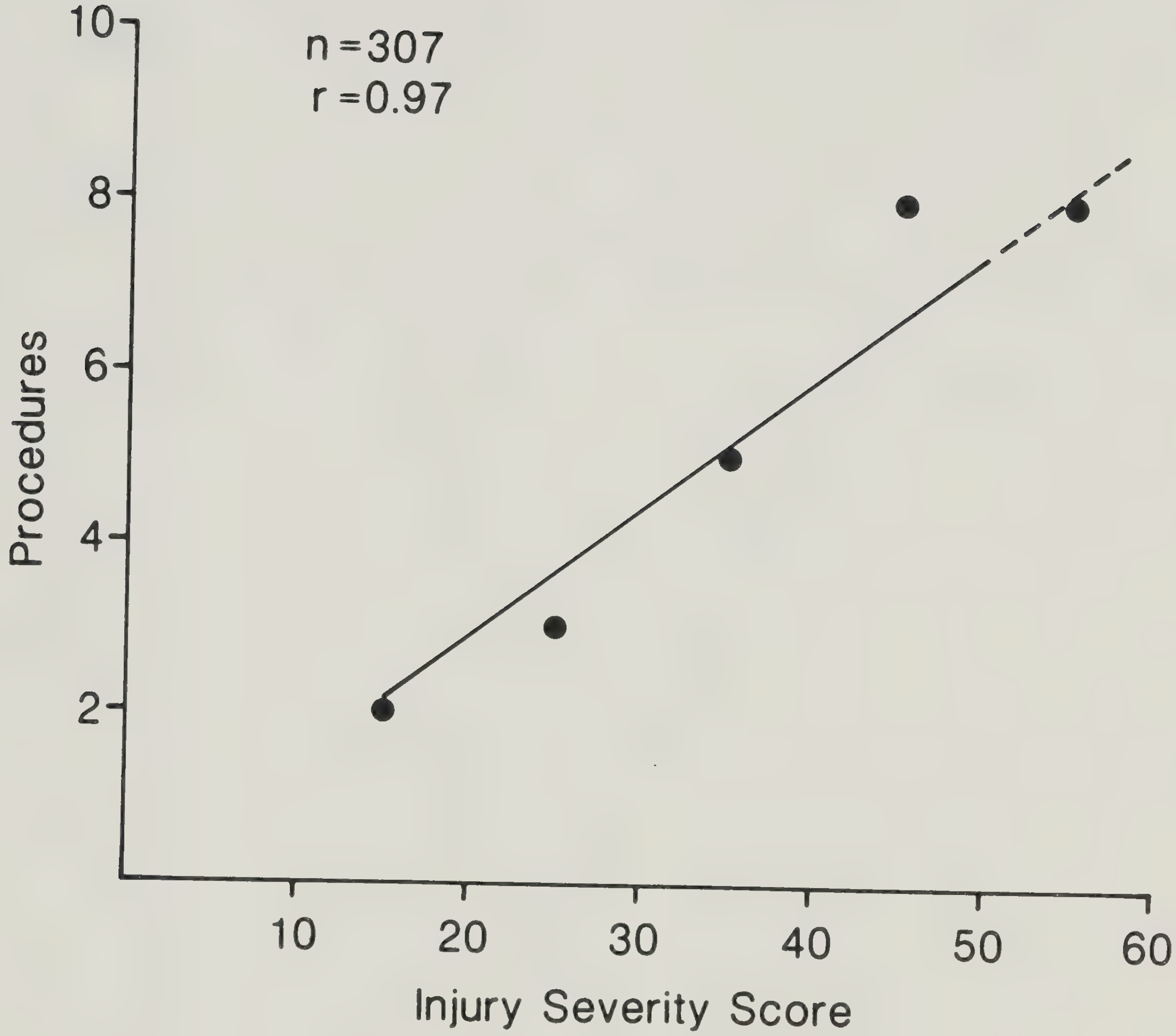
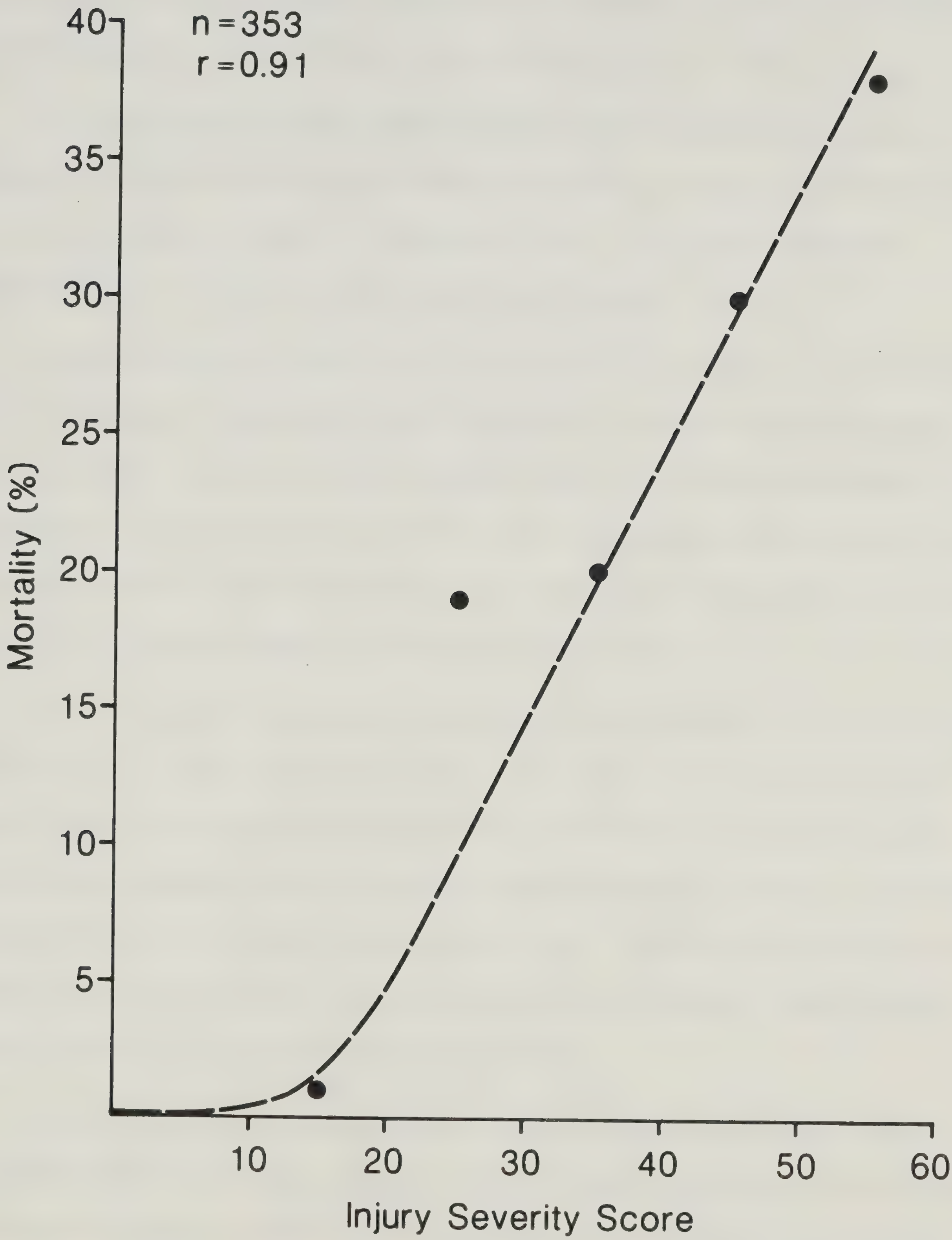

n =307
r =0.97
10
8
6
4
2
Procedures
10
20
30
40
50
60
Injury Severity Score

Figure 10


n = 353
r = 0.91
40
35
30
25
20
15
10
5
Mortality (%)
10
20
30
40
50
60
Injury Severity Score

head and spinal injuries (n = 101) and all other injuries (n = 81) the cause of this increased mortaltiy becomes apparent. The mortality of the 101 patients with isolated head and spinal injuries was 27 percent. The mortality of all other injuries in this group (n = 81) was 9 percent. The difference is statistically significant (χ^2, $p < 0.01$).

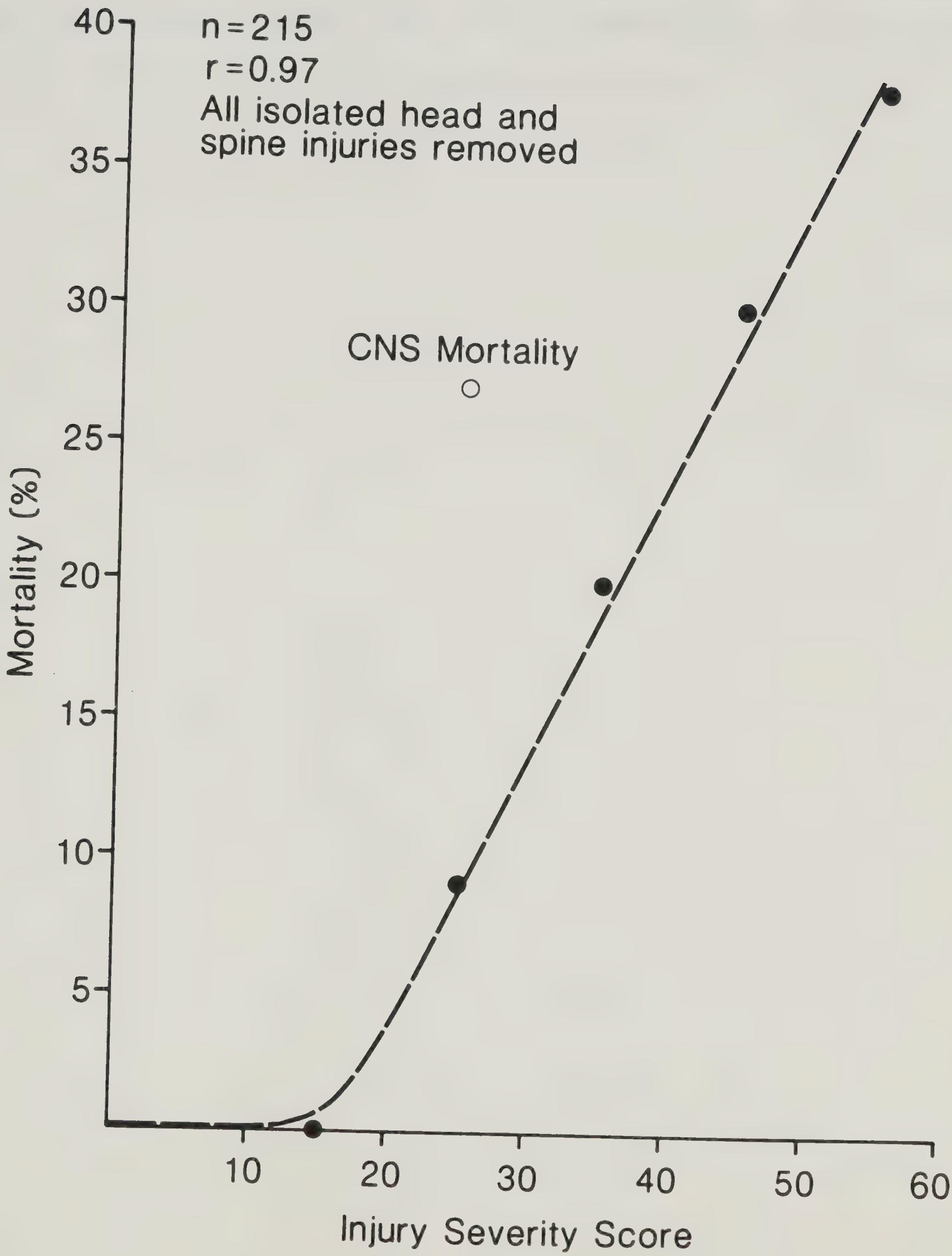
If the curve of Injury Severity Score versus mortality is then re-drawn, without the isolated head and spinal injuries, an improved fit (r = 0.91 versus r = 0.97) is attained (Fig. 11). This difference however, does not attain statistical significance.

As stated earlier there were 47 deaths for an overall mortality rate of 13.3 percent. The deaths were classified into CNS related and non-CNS related. Any patient with a head injury that had an Abbreviated Injury Scale value of greater than 3, was considered to have died of CNS related causes. Using this definition, there were 9 non-CNS related deaths and 38 CNS related deaths in the study population.

This group of 47 patients consists of those patients dying in the hospital i.e. after formal admission. This does not include patients that died in the Emergency Department. Of the nine patients that died of non-CNS related causes, autopsies were performed in seven. The average Injury Severity Score of this group was 31.4. Of the thirty-eight patients that died of CNS related causes, sixteen had an autopsy. The average Injury Severity Score of this group was 28.4.

All of the patients that died in the Emergency Department were considered Medical Examiner's Cases. In 1979 there were fifteen such cases related to trauma. All of these patients underwent external autopsies

Figure 11


n=215
r=0.97
All isolated head and spine injuries removed
CNS Mortality
Mortality (%)
40
35
30
25
20
15
10
5
10
20
30
40
50
60
Injury Severity Score

but only four had a formal autopsy done. Unfortunately this hinders the application of the Injury Severity Score as the required information is not complete. The average Injury Severity Score of the four patients that were autopsied was 45. The remaining eleven patients were dropped from the study because of the inadequate information.

CHAPTER 5 DISCUSSION OF RESULTS

5.1 The Multiple Trauma Patient Population

In performing this retrospective study of multiple trauma patients treated at University of Alberta Hospital in 1979 an accurate estimate of the magnitude of the problem has been obtained.

In actual numbers, the University of Alberta Hospital, treated 2186 patients in 1979 which is comparable to other major hospitals in the United States[4] and in Britain.[17] When classified by the Injury Severity Score, (Table 4) the 353 patients with a score greater than 10 represents a typical profile of multiple trauma patients seen in these centers. Additionally, the age distribution and sex ratio are typical of most trauma units.[4,17]

5.2 The Rural Accident Victims

Of the multiple trauma victims studied, 236 (67 percent) came from outside the city of Edmonton (Table 3). In fact, 40 percent came from greater than 150 kilometers away. It is of interest that the average Injury Severity Scores of the rural and urban patients do not differ. One might have expected that the more severely ill patients in rural areas would be transferred and that this group would have a higher Injury Severity Score with its attendant higher mortality. There was a trend towards a higher mortality in the rural areas as shown by the 13.6 percent mortality for all rural patients and the 17.5 percent mortality of those patients originating from more than 150 kilometers distance. Within this subset of patients there was a high proportion of isolated head injuries

as will be discussed below. These patients have a high mortality but a maximum Injury Severity Score of 25.

5.3 A Comparative Evluation

In assessing the patients in the study that died, an average Injury Severity Score of the CNS related and non-CNS related deaths was obtained. For CNS related deaths the average score was 29.6 and for non-CNS related deaths the average was 32.5. These figures account for the in hospital deaths and four of the fifteen deaths that occurred in the emergency department. It was possible to include those four emergency room patients that had a complete autopsy by the Medical Examiner of Alberta.

As previously cited, the study by West et al, evaluated the systems of care in Orange and San Francisco Counties, in California. A comparison of the average Injury Severity Scores of all patients that died after arrival at hospital was made. Each group was divided into CNS and non-CNS related deaths. The average Injury Severity Score in San Francisco County was 45 for non-CNS deaths and 46.5 for CNS related deaths.

A true comparison is not possible with the experience at University of Alberta Hospital because of the lack of data on those patients that died in the emergency department. However, it appears that the difference in the Injury Severity Score of both CNS and non-CNS related deaths is significant. This would suggest that the level of care offered at the University of Alberta Hospital is below that offered in San Francisco County. (Table 5).

Other differences also exist between the two patient populations. The trauma victims in San Francisco County arise out of a population of 1.7

TABLE 5

Comparison of Average Injury Severity Scores in Non-CNS Related Deaths

	Number of Patients	Average I.S.S. non-CNS Related Deaths
University of Alberta Hospital 1979	10	32.5
Orange County	30	37.0 *
San Francisco County	16	45.0 *

* statistically significant ($p < 0.03$)

West et al, Systems of Trauma Care, Arch Surg Vol. 114, 455-460, April 1979

million in an area 2,033 square kilometers. The University of Alberta Hospital serves a population of 1.2 million spread over an area tens of thousands of square kilometers. As previously stated 40 percent of the patients come from greater than 150 kilometers away.

Additionally, San Francisco County is served by a trauma unit at the San Francisco General Hospital and it has a full network of communications and rapid transport available to it. The system at University of Alberta Hospital is less well defined and the majority of patients are seen at a primary care facility prior to transportation to the tertiary care center.

Despite these discrepancies, there is a strong suggestion that the level of care offered by the present unstructured system at University of Alberta Hospital could be improved. This problem needs to be properly studied in a prospective fashion. What will be needed is complete and accurate information of all patients dying secondary to trauma. If we are to accurately assess our level of care, a complete autopsy must be performed on all of these victims.

5.4 The Role of the Injury Severity Score

The second goal of this research project was to work with the Injury Severity Score so that its applicability could be evaluated in detail. In doing so further documentation of the Injury Severity Score as a measure of morbidity and mortality has been obtained. This has reinforced one of the expressed hopes of the original authors,[4] that it be a simple index to use and that it can be universally applied. The universality has been attained by basing it on the International Classification of Diseases

Code. Simplicity of utilization has been realized because of its foundation on the final diagnosis and the Abbreviated Injury Scale. It is not however, without its deficiencies and will require further modification to attain greater accuracy.

As an index of morbidity the Injury Severity Score is an accurate measure. In this study two parameters of morbidity were chosen to compare with the Injury Severity Score. When plotted against the length of hospital stay, (Fig. 8) a linear relationship with a high degree of correlation in the surviving patient population was found. This confirms the findings of Semmlow and Cone.[65] In a study of traffic casualties in Birmingham, Bull[17] also found a relationship between length of hospital stay and Injury Severity Score in patients with scores of less than thirty. This relationship was not linear and a correlation coefficient was not given. The fact that the Injury Severity Score correlates so well with hospital stay relates to its derivation from the Abbreviated Injury Scale. It should be recalled that treatment time if one of the variables considered in assigning this value.[26]

The second parameter of patient morbidity compared with the Injury Severity Score was surgical procedures. This comparison was also confined to the survivors. As shown in Fig. 9 a linear relationship with a high degree of correlation was found. In comparing the Injury Severity Score with the proportion of patients undergoing major surgical procedures Semmlow and Cone[65] also found a linear relationship. In their definition a major surgical procedure was one providing major care during the acute post-traumatic period. In the study done at University of Alberta Hospital all surgical procedures were tabulated. The inclusion of all surgical procedures (i.e. tube thoracostomy, blood transfusion, tracheostomy etc.)

was made to more accurately reflect morbidity in that large group of blunt trauma patients who require intensive treatment but do not necessarily undergo major surgery.

The relationship between the Injury Severity Score and mortality is a non-linear function with a high degree of correlation. The curve plotted is similar to the original relationship found by Baker et al.[4,5] In the curve depicted in Fig. 10 the point scatter is minimal with the exception of the point representing the Injury Severity Scores twenty to twenty-nine. As previously discussed, thirty-nine percent of the patients in the study suffered isolated head and spinal injuries. In a single system injury the maximal Injury Severity Score attainable is twenty-five. Seventy-three percent of these isolated neurological injuries fall into the group of patients with scores twenty to twenty-nine, forming 56 percent of that group. The mortality of the group as a whole was 19 percent, not significantly different from the mortality of 20 percent for patients with a score of thirty to thirty-nine. The reason for this upward distortion is the large group of patients with isolated head and spine injuries and the associated higher mortality.

As discussed earlier in patients with an Injury Severity Score of twenty to twenty-nine, the mortality of those with head and spinal injuries was found to be significantly greater than those patients with a similar score, but with other types of injuries (χ^2, $p < 0.01$). As shown in Fig. 11, when the patients with isolated head and spinal injuries are removed from the study group, the function of Injury Severity Score versus mortality improves. Because of this fact, any study population with a large number of isolated head and spinal injuries will have a higher mortal-

ity than predicted by the Injury Serverity Score curve. It is thus concluded that a higher level of accuracy can be attained by excluding these isolated neurological cases. Alternately, by assigning them a higher Abbreviated Injury Scale value a higher mortality will be reflected in a higher Injury Severity Score.

Within these constraints the Injury Severity Score does have a role in the comparative evaluation of the care of the trauma patient. Severity indices as s whole have a number of functions. Firstly they are useful for epidemiological studies and comparative evaluation. Secondly they can be used as a measure of the input into medical system to be evaluated. Thirdly, some indices can be used for patient triage. Lastly, these indices can be used for prediction of outcome.[19]

Within the above mentioned functions, the specific role of the Injury Severity Score must be defined. It is not a triage index and should not be used as such. Because of its derivation from the anatomical diagnosis, it relies on complete information and proper coding to be accurate. Such information in the pre-hospital or emergency room phase of treatment is usually not available.

The primary role of the Injury Severity Score is as a measure of input into an emergency medical system. This also allows it to be used in epidemiological studies and in comparative evaluations. An example of how the Injury Severity Score can be used in such work is the study by West et al,[77] cited earlier in this paper.

Lastly, the Injury Severity Score does function as a predictor of mortality. The accuracy of such predictions rely on the accuracy of the

calculation of the Injury Severity Score. Further work is needed to establish and define mortality rates at the high end of the scale (Injury Severity Score > 40). Most studies to date are dealing with relatively small numbers of patients in this range of scores and consequently the published mortality rates do vary significantly. In their original paper, Baker et al[4] found new survivors (mortality = 90 percent) with a score of greater than fifty. In the study at University of Alberta Hospital, as in others[17,65] a number of survivors have been documented, in fact the mortality rate in this series for patients with an Injury Severity Score to fifty to fifty-nine was 38 percent. The two series are separated chronologically by ten years which may acccount for some of the difference. Another fact may be in the application of the codes and calculation of the Injury Severity Score. Further work is needed in standardizing the disease codes and modifying the Abbreviated Injury Scale. Such work can only be done by cooperation amongst centers.

Finally, as a measure of outcome, the Injury Severity Score, has (with one exception) been compared only to mortality. Bull[17] has made the one attempt at correlating the Injury Severity Score with disability. Further attempts are warranted and would be facilitated by the creation of an accurate and usuable index of disability. While death is the most finite outcome measure, its presence or absense may not as accurately reflect the efficacy of various therapeutic interventions on the trauma patient.[19]

CHAPTER 6 THE TRAUMA UNIT CONCEPT

6.1 Development of the Concept

Through-out the foregoing paper, many references to the "trauma unit" concept have been made. In studying the multiple trauma patient population at the University of Alberta Hospital in 1979, the system of care being examined is one that is unstructured yet has available to it all of the services and skills of an up to date tertiary care center. Many articles have appeared in the literature[10,28,54,55,56,76,77] to suggest a more structured approach to the seriously injured accident victim is more efficacious. Indeed, the comparison of Injury Severity Scores of patients dying at the University of Alberta Hospital and the San Francisco General Hospital would support this argument. In order to appreciate the two major systems of care being offered it is appropriate to describe each, with particular emphasis on the concept of the trauma unit.

In the unstructured system of care currently in existence across Alberta, the injured patient is taken from the accident scene to the nearest hospital by ambulance. The ambulance crew may consist of untrained personnel or fully trained emergency medical technicians. On arrival at the hospital, therapeutic and diagnostic procedures are started. If the hospital is capable of handling the particular medical problem, it would do so, otherwise the patient would be transported to a secondary or tertiary facility where treatment would be forthcoming. The distances and time required for such transport vary greatly, depending on the locality involved, be it urban or rural. The unfortunate consequence of this system is that the more severely injured patient, requiring the tertiary care center, has

the longest wait prior to definitive care. It is the delay involved in treating this group of patients that has led to the development of the trauma unit concept.

Despite the fact that in Canada 15,000 people per year die an accidental death,[18] until recently very little has been done to propose modifications in the traditional method of treating the accident victim. Much of what has been written in the English medical literature comes from the United States, where tremendous impetus to the emergency medical services systems was provided by federal programs in the early 1970's.[10,13,78] Within the framework of the emergency medical system has grown the concept of the trauma unit. The emergency medical system must be designed to handle all types of medical emergencies however, the traumatized patients form the largest subset within the emergency patient population. As with most critical illnesses they require a team approach integrating many aspects of medical care.

The basis of the trauma unit idea grew out of the American experiences in the Korean and Vietnam wars.[10,28] One of the main factors affecting mortality is the time from injury to definitive care. Analysis of both military and civilian casualties reveals a direct relationship between mortality and the interval from injury to proper therapy. The care of the injured patient is not a single act. It must be a coordinated, ordered, sequence of events that delivers optimal care in the shortest amount of time.[10]

6.2 Principles of Care in the Trauma Unit

For this ordered sequence of events to occur, a properly planned system of care must be available. This requires planning and organization at the local and regional level. An absolute requirement is professional cooperation and support. The trauma unit must work towards the inclusion of the peripheral centers and it must be flexible enough to meet the needs of a changing community. In addition to its fundamental role as a provider of medical care, the trauma unit must function as a teaching center, not only for the medical profession, but also for the paramedical groups on which it so heavily relies.[9,10]

Several principles in the approach to the trauma patient have been established. The initial trauma unit in the United States was established in Illinois in 1966.[9] In describing this unit, Boyd [9] and others[54] have elaborated on these principles which include:

1) immediate identification of the injured patient and provision for transport to the trauma care area

2) triage of all hospitalized trauma victims in a single location by a single team of experienced surgeons

3) resuscitation and comprehensive initial evaluation in a single fully staffed and equipped area of the trauma unit

4) utilization of a team approach to the individual patient with the general surgeon or orthopedist functioning as a team coordinator

5) upgrading the level of training of the trauma team coordinator to that of a senior experienced surgeon

6) establishment of an integral intensive care area dedicated to the needs of the critically injured patient

7) specially trained nurses and other health professionals developed to staff the unit, with continuing education courses for these personnel

8) consolidation of all related hospital resources for the injured patient in this central location

9) necessary supporting laboratory services available in the unit itself

10) establishment of a priority system in the hospital's x-ray department and blood bank, in which trauma patients are given appropriate priority at any time.

These principles have been incorporated into guidelines established by the American College of Surgeons.[2] These guidelines propose the establishment of a three tier system of hospital care - Level I, optimal, Level II, intermediate and Level III, minimal - reflecting the services available at a particular hospital. Recent proposals have included specific levels of training as a requirement for personnel staffing such a unit.[72]

6.3 Demand for a Trauma Unit

Those who are familiar with the running of a large general hospital will realize that the commitments outlined in the guidelines and principles above require an enormous investment in planning and personnel. This will inevitably bring about questions of cost effectiveness. Most of the services required already exist in tertiary care hospitals associated

with university centers and so it is logical that these centers contain the trauma unit. American estimates[10,77] suggest that approximately one thousand patients per year are required to make such a center worthwhile economically. It is further estimated that approximately five percent of patients injured in motor vehicle accidents will require the full services of a trauma center.[77]

The demands of a given community on a given trauma unit will necessarily reflect the pattern of injury in that region. In blunt trauma due to motor vehicle accidents, head injuries alone represent thirty-five to forty percent of cases. It is estimated that the vast majority of these will require the care of a trauma unit. Additionally a high percentage of burns and spinal cord injuries will need the complete services of such a unit.[10]

6.4 The Rural-Urban Model

The population distribution within a given region will determine the nature of the activities carried out by any given institution within the regionalized system. In sparsely populated rural areas the hospitals that would be classified as minimal (Level III) by the American College of Surgeons, will at times have to function as resuscitation and transport units. Because of the vast distances to be covered, proper evaluation and resuscitation must be carried out prior to transport.

As previously mentioned, accidents in rural areas continue to pose a serious problem to trauma health care delivery. These rural accidents occur at higher speeds and away from potential sources of help, thus

leading to significant delays in ambulance service. This is reflected in a significantly higher mortality for rural accident victims.[76] Furthermore, because of the scattered population, no one institution in the rural area encounters enough major trauma patients to warrant major investment in the upgrading of services. It rests with the Level I center to provide the rural areas with ongoing educational and training services.

Within the urban district one medical center functions as the trauma unit. A network of communications and rapid transport is established to minimize treatment delays. In centers with severe traffic congestion aerial transport, usually by helicopter, can be utilized. This system will necessarily tie into the network of referral centers in the rural districts so that the transport of patients that require the Level I hospital is quick and efficient. What should evolve is a team of highly skilled personnel that is always available so that at any point in time a patient within the network is properly evaluated, resuscitated, and transported.[10,28]

Perhaps the most important corner stone on which the regionalized care of the trauma patient is built is the cooperation necessary within the medical profession. The profession within the hospital designated as the optimal care (Level I) center must be cognizant of the tremendous burden this will place on that particular institution.

That five to ten percent of patients requiring the full services of such a hospital will alter the general hospital routine in that they will require more investigations, more procedures and more hospital bed days than most patients. In addition they will require more support staff while in the critical phase of their illness.

Cooperation from the medical profession in the peripheral centers is also extremely important. The establishment of a tiered system of care must not be seen as a patient grab, but rather as a genuine attempt to improve medical care and improve the cost effectiveness of such care. The peripheral centers must be included in the decision making process at the local and regional levels and where the situation warrants it, included in the actual delivery of health care to the injured patient. Such structuring of health care is not unique in that a similar model exists for the cancer patient.

CHAPTER 7 EVAULATION OF EMERGENCY MEDICAL SYSTEMS

7.1 The Need for Evaluation

The establishment of a trauma unit involves a large investment in manpower and capital equipment. Such investments require money from the public sector and where such public funds are spent, the justification for these expenditures must be met. Therefore, the effectiveness of such a system must be measured, and critical ongoing evaluation of its performance is necessary. Does such a system of care for the injured patient decrease mortality? Are these 'response measures' i.e. rapid transport, paramedics working in the field etc., more effective than 'preventative measures' i.e. seatbelt legislation, lower speed limits? How many 'salvageable deaths' are there in any given community? Such questions must be answered by the medical profession for its own benefit, and also for the benefit of the community at large.

7.2 Current Methods of Evaluation

Attempts at evaluating the care of the injured patient have met with criticism,[37,38,39,78,79] much of it valid. Reviewing the literature on the efficacy of the trauma unit reveals a wide range of opinions as to how effective or how ineffective they are. The conclusion one is forced to draw is that adequate evaluation is difficult and is usually not done. Inevitably one becomes familiar with authors that are pro or con a given issue. This loss of objectivity reflects the difficulty in clinical research of dealing with many variables in any given study. Consequently the lack of precision in measuring these variables may invalidate the

conclusions of that study.

An example of the pro trauma unit forces can be taken from a study by Waters and Wells[76] who studied their system of care in Jacksonville, Florida. They found a 38 percent decline in the rate of deaths per accident and a 24 percent decline in the rate of deaths per person injured when they compared data from a functional trauma unit to the pre-trauma unit period. In studying the cause of death in those killed they found only three of one hundred fourteen to be potentially preventable. This led them to make the statement that they ... "may have reached an irreducible fatality rate within the constraints posed by the traffic environment, and perhaps should concentrate on the prevention and crash phases while still retaining our highly effective post-crash emergency response organization." Their data would tend to support this statement, however, the study concentrated only on the outcome and this can cause erroneous conclusions as will be discussed below.

Indeed many studies do focus purely on the outcome of a given procedure or system of care. This is not unique to the literature on emergency medical systems. As a result of this improper evaluation, the efficacy of emergency medical systems is strongly questioned. In reviewing this situation, one researcher[38] was led to comment that "there is little in the research literature to disprove the possible notion that the emergency medical system is dealing with a finite set of patients who are going to die or survive solely as a function of their condition and that the only effect of emergency medical system expenditures is in influencing when and where death takes place."

7.3 A Model for the Evaluation of Emergency Medical Systems

Such a statement, raises serious doubts about the effectiveness of the trauma unit. Few of the profession working in this area would be as enthusiastic as Waters and Wells in suggesting that an 'irreducible fatality rate' can be achieved, but most would argue strongly that the aggressive methods of care do save patients that would otherwise have died. Unfortunately the medical profession has been slow to allow for a thorough evaluation of these systems of care. The result is that the techniques of evaluation have not been adequately developed. As Willemain,[78] points out, the complexity of the medical system being evaluated has gone beyond the capabilities of the clinical researchers trying to measure it. To measure a given system only by its outcome is valid only for a given point in time. Outcome will be a function of what entered the system and how it was treated. To compare two systems or to compare one system at different points in time, by measuring only outcome is inaccurate. A proper comparison requires that the other variables in the equation be controlled. In most medical situations there are a large number of independent factors at work. It may not be possible to control all variables however, attempts must be made at controlling those factors that have the greatest probability of affecting outcome.[79]

If one is to effectively evaluate a problem in health care there are three phases that need to be identified and quantitated. These three phases are: the input, the through-put or processing and the output. To concentrate on only one phase ignores the interrelationship of the three phases and will relatively invalidate any conclusions drawn.

7.31 <u>The Input Phase</u>

Perhaps the easiest phase to measure is the input. Initially, the type of material that was collected as a measure of input related to counts of vehicles, personnel, service incidents, ambulance equipment, level of training of personnel and operative procedures.[78] In a study of such measures as used across the United States, Gibson,[37] proposed resource to population ratios as being more accurate. An example of this is ambulances per capita and ambulance runs per capita. In 24 cities studied a wide variety of ratios was found. An optimal ratio was difficult to define as the characteristics of ambulance function (i.e. length of each run) varied by community. This represents a fundamental problem with this type of information. Resource to population ratios are too crude and do not allow for variations in demography, geography and personnel skills within the study groups being compared. Additionally, other factors often measured such as doctors per capita and emergency rooms per capita, ignore the demand on these services, which is not necessarily a direct function of population. Within any two regions there may be a similar ratio of a given resource but the distribution of that resource across each region may be vastly different. This fact would also be hidden in this type of statistic.[78]

Until recently, it was evident that an optimal measure of input was lacking. This led to the development of the illness severity indices discussed earlier in this paper. Because outcome is a function of input and through-put (treatment rendered), to properly compare outcomes of two different systems of care as a measure of their effectiveness (processing)

one must control the other variable, the input.[19]

Many indices of severity have been developed as discussed earlier. In using such indices as a measure of input into a given system, the appropriate index must be used for a given phase of treatment. For example, a triage index such as the trauma score would be useful as a measure of the function of the pre-hospital phase in the care of the trauma patient. It would not however, be appropriate to use it as the sole measure of input for evaluating all phases of care for the injured patient. A more appropriate index for this situation would be an anatomical index such as the Injury Severity Score which can be derived only when complete and accurate information is available. This will allow for the standardization of data on groups of patients with multiple injuries.

7.32 The Through-put Phase

The second phase to be measured in a system of care is the through-put or processing phase. The primary purposes of such evaluation is to measure the appropriateness of the system's resource utilization. Examples of such measures would be the time involved in an ambulance run, the accuracy of telephone and on the scene triage and the appropriateness of particular diagnostic and therapeutic procedures. It would be necessary to critically evaluate the diagnostic and therapeutic decisions made to accurately measure the efficacy of resource utilization and to evaluate the processing of the patient.[37,78] The parameters to be evaluated are much more complex than the input criteria. The processing measures are the dynamic component of a particular system of care, the input measures

are the static component. Decisions made with regard to the appropriateness of these procedures must necessarily be made by the medical profession (doctors, nurses etc). These decisions will require adequate information, often missing from the medical charts, if they are to be accurate and useful. The collection of such information should be done prospectively and stored in a trauma registry. It would be a function of the medical staff involved in the care of these patients to ensure the accuracy of this data.[78]

7.33 The Output Phase

The last phase and perhaps the most useful when considered together with the other two phases is outcome. The outcome should be a direct function of input and through-put (processing). The most commonly used measure is death. It is finite and easily measured. It does however, ignore the morbidity of a given disease and the permanent disability associated with some injuries. Presently, few attempts have been made to standardize the measurements of non-fatal outcomes, although the Glasgow Outcome Scale,[47] a measure of a range of possible outcomes after head injury, is a beginning.

If one uses outcome as the only measure of a given system's efficacy, inaccuracies will arise. As stated earlier the initial reports on the effectiveness of trauma units revealed higher mortalities at the hospitals involved, after the institution of the unit. Failure to control the input variable in the group of patients entering the system led to this erronous conclusion.[6,9,39]

With adequate, accurate data encompassing all phases of emergency medical care, it should be possible to establish a range of outcome norms for a given injury. Such norms, based on peer review, would enable detailed study of those regions that vary significantly from the norm. Additionally, by establishing acceptable case fatality rates for a given injury, a standard of care to be attained would be established. This information is not only for the use of the medical profession but also for use by the community at large. These standards would aid in decision making for the allocation of public funds. Such decisions are falling increasingly into the political arena, away from the medical profession, in the era of socialized medicine. It is important that the decision makers have adequate and accurate information at their disposal. In any one community there will be a certain mortality associated with accidents of all types. It is the "salvageable" deaths that a properly functioning trauma unit aims to decrease. The decision on what constitutes medical salvageability is the decision of the profession. The decision to save or spend the incremental dollar to lower the number of "salvageable" deaths is a social and political one.[78]

CHAPTER 8 CONCLUSIONS

The results of this study enable a number of conclusions to be drawn. First, there was a significant number of injured patients treated at University of Alberta Hospital in 1979. The study done on these patient's has allowed for a definition of the problem of the multiple trauma victim at that point in time. Efforts to expand the scope of the study and establish it as an ongoing prospective study must be made. It should be possible to expand the data collection to include all of the regional centers (i.e. Grande Prairie, Red Deer, Fort McMurray, etc) and hopefully all of the primary centers too.

Second, the information presently collected in the medical records is inadequate. The data collection should be set up to critically evaluate the care of the trauma patient. The information gathered should be expanded to include not only data pertaining to billing the health care plan, but also data more reflective of health care delivery i.e. time interval from injury to therapy, complications, impairment, etc. In so far as the government run health care insurance plan has the ability to collect all of the billing data, it should be possible and inexpensive to expand their mandate to include relevant data on the trauma patient.

For this type of prospective study to be accurate,more information pertaining to all accident victims, but especially fatally injured victims, must be retrieved. The present situation with regard to medical examiner's cases represents the most florid example of a missed opportunity to obtain accurate information. The fact that only four of a total of

fifteen medical examiner's cases had formal autopsies is unacceptable. For educational purposes alone, a formal autopsy should be done on all victims dying in the emergency department. To properly evaluate our health care delivery system, it is imperative that we have an accurate estimate of the salveagable deaths that are occurring. This will require an autopsy on all motor vehicle accident victims dying as a result of their injuries, either in hospital or pre-hospital.

It should ultimately be possible to integrate the data collected by the medical, ambulance and police teams involved in any accident in the province. Such integration will allow decisions to be made on the therapeutic and preventative aspects involved in any accident. For example, a particular intersection near a local bar could be identified as a health hazard because of any of a number of factors i.e. impaired drivers, poor lighting, slow ambulance response time and prolonged transport time to hospital. Correction of the identified problem will improve the well being of the population. Such a method of data collection currently exists in Manitoba.

The third and final conclusion is that the Injury Severity Score constitutes a valuable tool in evaluating the care of the critically injured. With the exception of the isolated neurological injuries, it serves as an adequate measure of mortality and morbidity. Its reliability is influenced by the level of accuracy with which the scores are applied. This requires specific anatomic diagnoses and avoidance of the "unspecified" codes in the ICD-9-C.M. system. Furthermore, full autopsies in patients that have died will increase the sensitivity of the Injury Severity Score.

Routine collection of data in any propsective study should include the classification of patients by the Injury Severity Score. This will allow for an adequate measure of the input into the medical care system. Most importantly it will enable comparative evaluation of health care systems. Such on-going evaluation is necessary, not only for the medical profession, but for the benefit of society as a whole.

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Appendix I: Study Questionnaire

MULTIPLE TRAUMA IN NORTHERN ALBERTA

Chart Questionnaire

1. Name: ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐
   surname, christian name, initial

2. Home Address: ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

3. Date of Birth: *day month year* ☐☐☐☐☐☐ *hospital* ☐☐☐ *unit number* ☐☐☐☐☐☐
   Code: UAH, RAH, EGH, MIS, CCH

4. Admission Month: ☐
   Code: 1-9 = Jan. to Sept., Oct., Nov., Dec. = 0, N, D.

5. Diagnosis:

		ICD 9-CM	AIS
primary	i)	☐☐☐☐☐	☐
secondaries	ii)	☐☐☐☐☐	☐
	iii)	☐☐☐☐☐	☐
	iv)	☐☐☐☐☐	☐
	v)	☐☐☐☐☐	☐
	vi)	☐☐☐☐☐	☐
	vii)	☐☐☐☐☐	☐
	viii)	☐☐☐☐☐	☐

6. Injury Severity Score: ☐☐

7. ICD Trauma Code: E☐☐☐☐☐

8. Site of Accident in Kilometers from Edmonton: ☐☐☐☐

9. Trauma Classification: ☐
   Code: 1 - blunt, 2 - penetrating

10. Operative Procedures

Hosp. Day:
* = within
6 hours

Procedures: ICD 9-CM

i ii iii iv

11. Surgeon:

12. Attending Physician:

13. Consultation:

14. Age:

15. Sex:

16. Admission Hour:

17. Admission Type: *if either column bland - elective*

Code: first column: 1) E - Emergency
2) U - Urgent
3) R - Readmission
second column: 1) A - Transfer from Acute Facility
2) S - Transfer from Nursing Home
4) T - Through Emergency

18. Disposition: [|]

Code: *blank - with approval to home, self-care*
X - against advice
T - to short term active treatment hospital
N - to skilled nursing facility
I - to intermediate care, nursing home
O - to other facility
H - to home health service
? - no entry

expired patients:

D - no autopsy
A - autopsy
1) P - post-op. death
2) O - died in O.R.
4) C - coroners case
8) E - died in E.R.

19. Hospital Service: [|]

20. Discharge/Separation Month: [ ]

Code: 1-9 = Jan. to Sept., Oct., Nov., Dec. = O, N, D.

21. Days in Hospital: [| |]

22. Days in Care Unit: [| |]

23. Payment: [ ]

Code: M - medicare, Canadian or U.S.
W - workers' compensation
V - title v or workers' compensation
I - insurance company
S - self-pay
Blank - no valid entry

24. Peritoneal Lavage: [ ] *Code: 0 - not done*
1 - negative
2 - positive